US007252547B2

(12) **United States Patent**
Nishide

(10) **Patent No.: US 7,252,547 B2**
(45) **Date of Patent: Aug. 7, 2007**

(54) **CONNECTOR**

(75) Inventor: **Satoru Nishide**, Yokkaichi (JP)

(73) Assignee: **Sumitomo Wiring Systems, Ltd.** (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/408,645**

(22) Filed: **Apr. 21, 2006**

(65) **Prior Publication Data**

US 2006/0240693 A1 Oct. 26, 2006

(30) **Foreign Application Priority Data**

Apr. 22, 2005 (JP) 2005-125406

(51) **Int. Cl.**
H01R 13/40 (2006.01)

(52) **U.S. Cl.** **439/587**; 439/275

(58) **Field of Classification Search** 439/157, 439/271, 272, 587, 589, 274, 275
See application file for complete search history.

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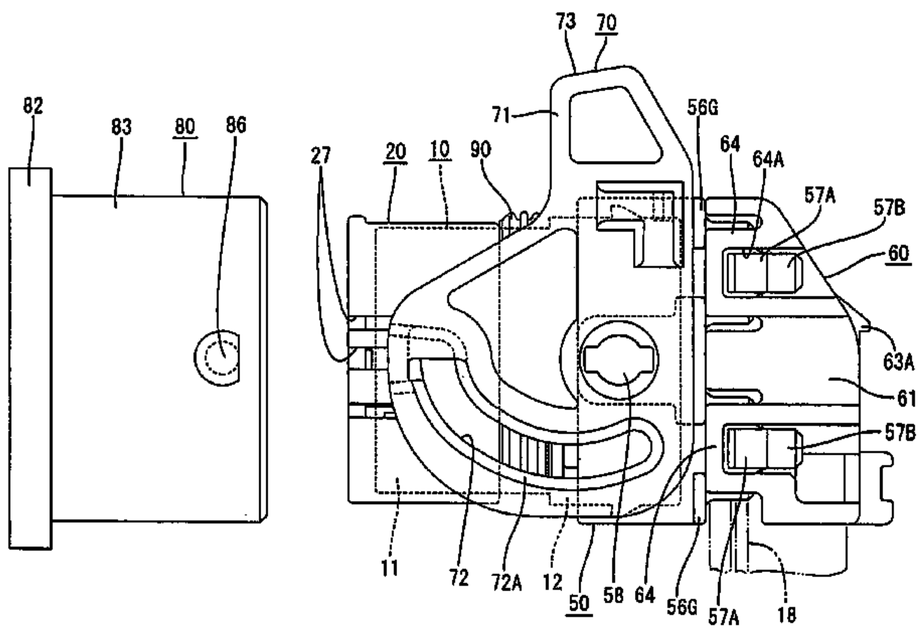
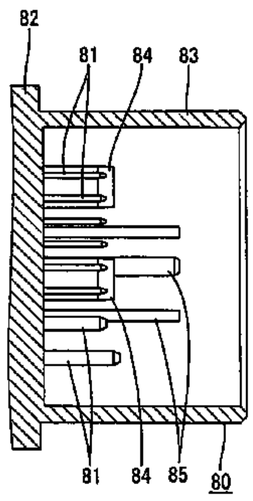
Primary Examiner—Hien Vu
(74) *Attorney, Agent, or Firm*—Gerald E. Hespos; Anthony J. Casella

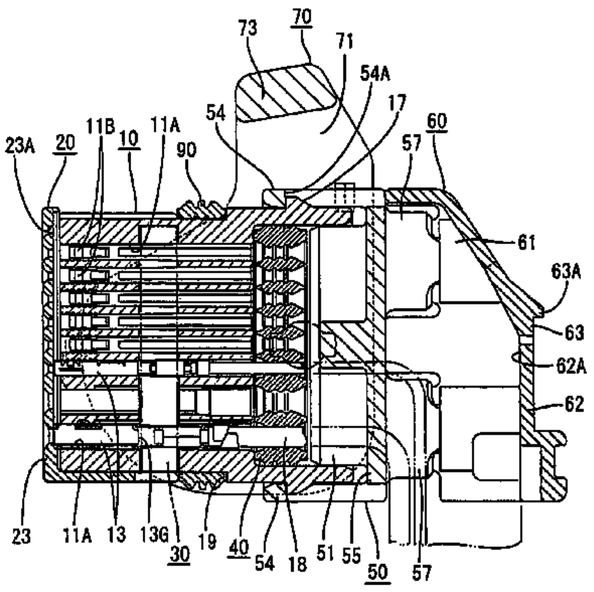
(57) **ABSTRACT**

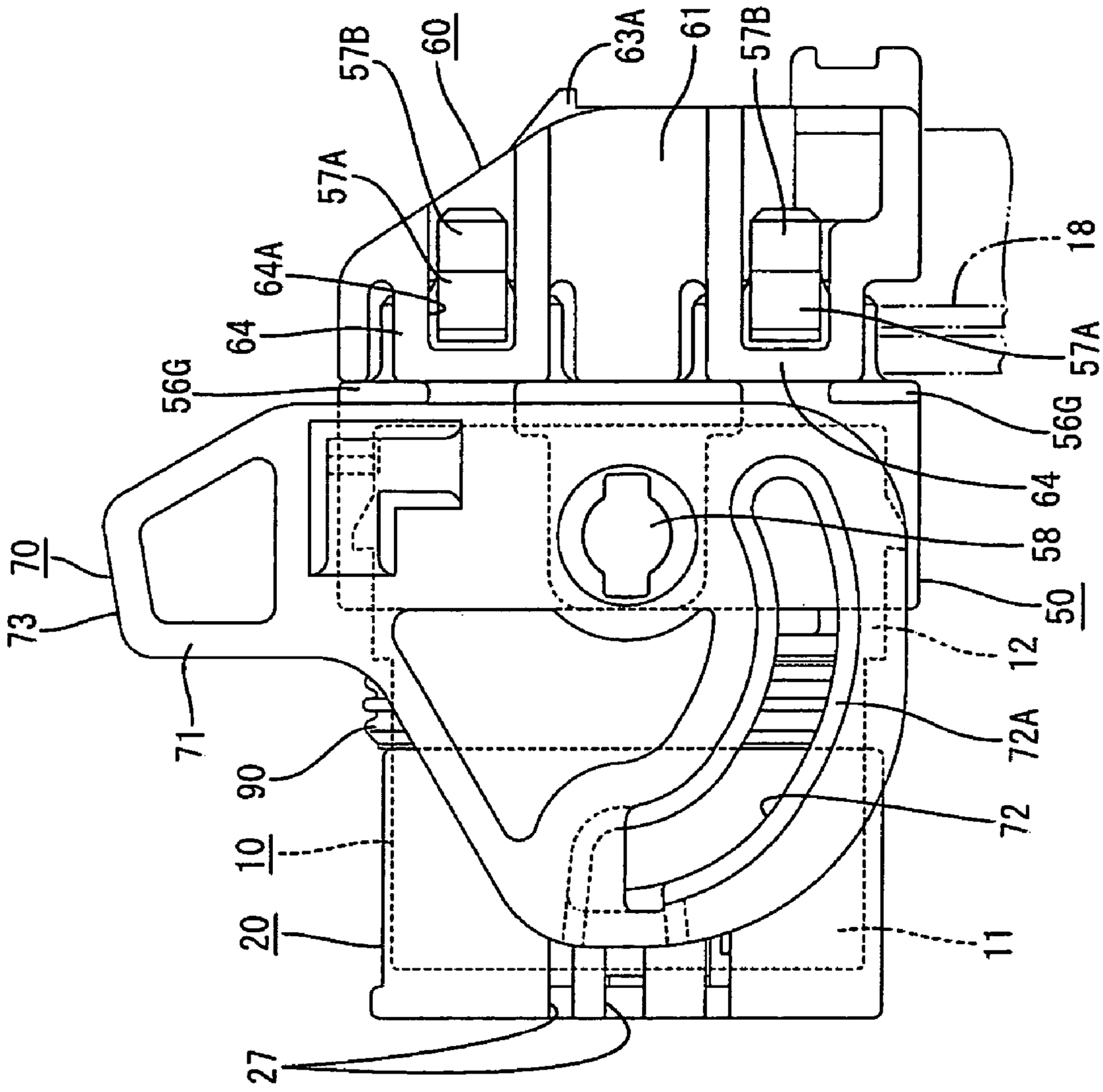
A connector has a female housing (**10**). A space (**12**S) is formed at the rear of the housing (**10**) for accommodating a seal (**40**) and terminal accommodating chambers (**11**A) extend forward from the space (**12**S). A rear holder (**50**) is mounted on the rear of the female housing (**10**) for holding the seal (**40**) in the space (**12**S). A lever (**70**) is mounted on the rear holder (**50**) and can generate a cam action for connecting the female housing (**10**) and a mating male housing (**80**). The lever (**70**) can be moved further after the housings (**10**, **80**) are connected for moving the rear holder (**50**). Thus, the rear holder (**50**) compresses the seal (**40**) into engagement with wires that extend from the female housing (**10**).

5 Claims, 27 Drawing Sheets





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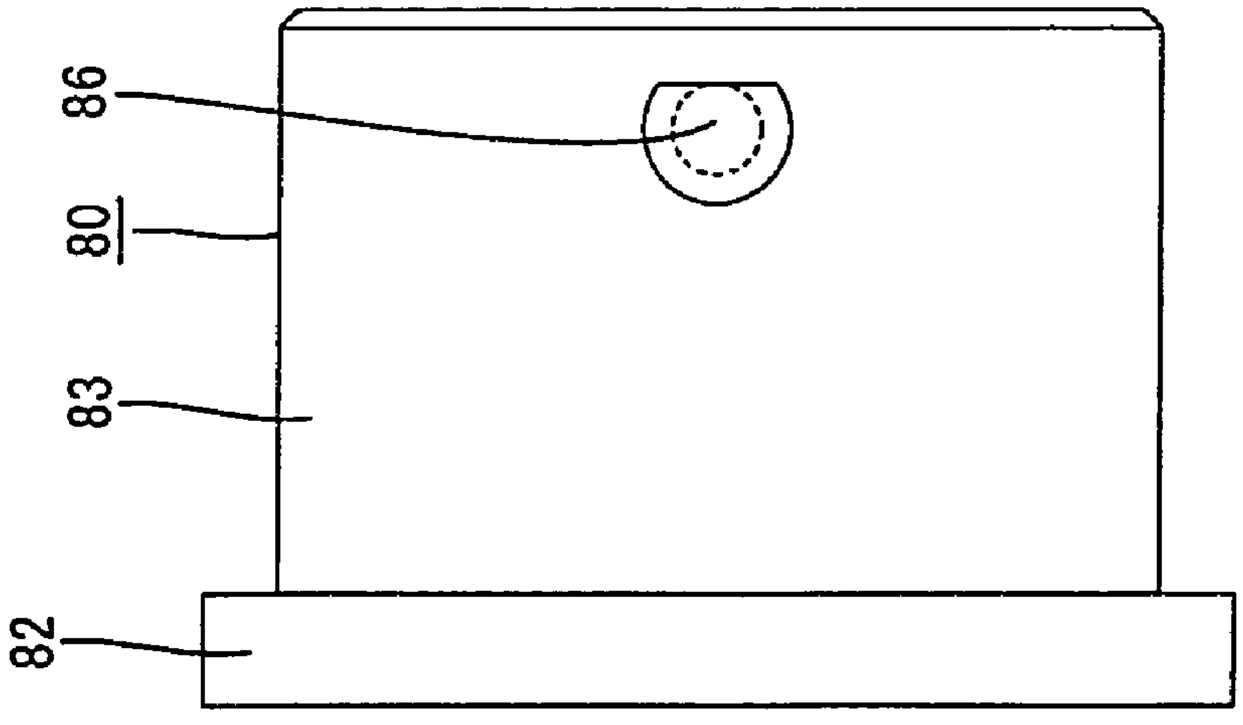
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FIG. 1

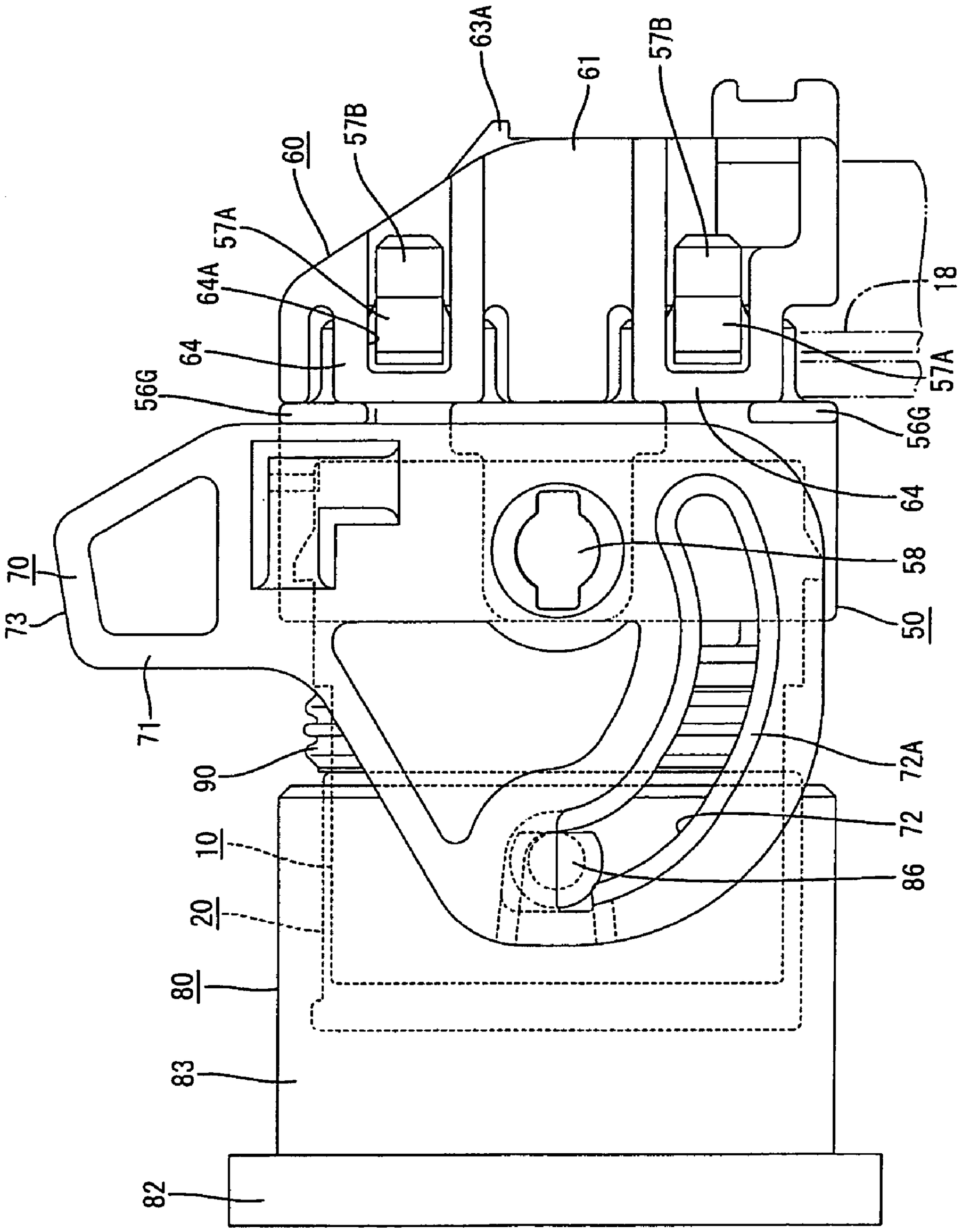
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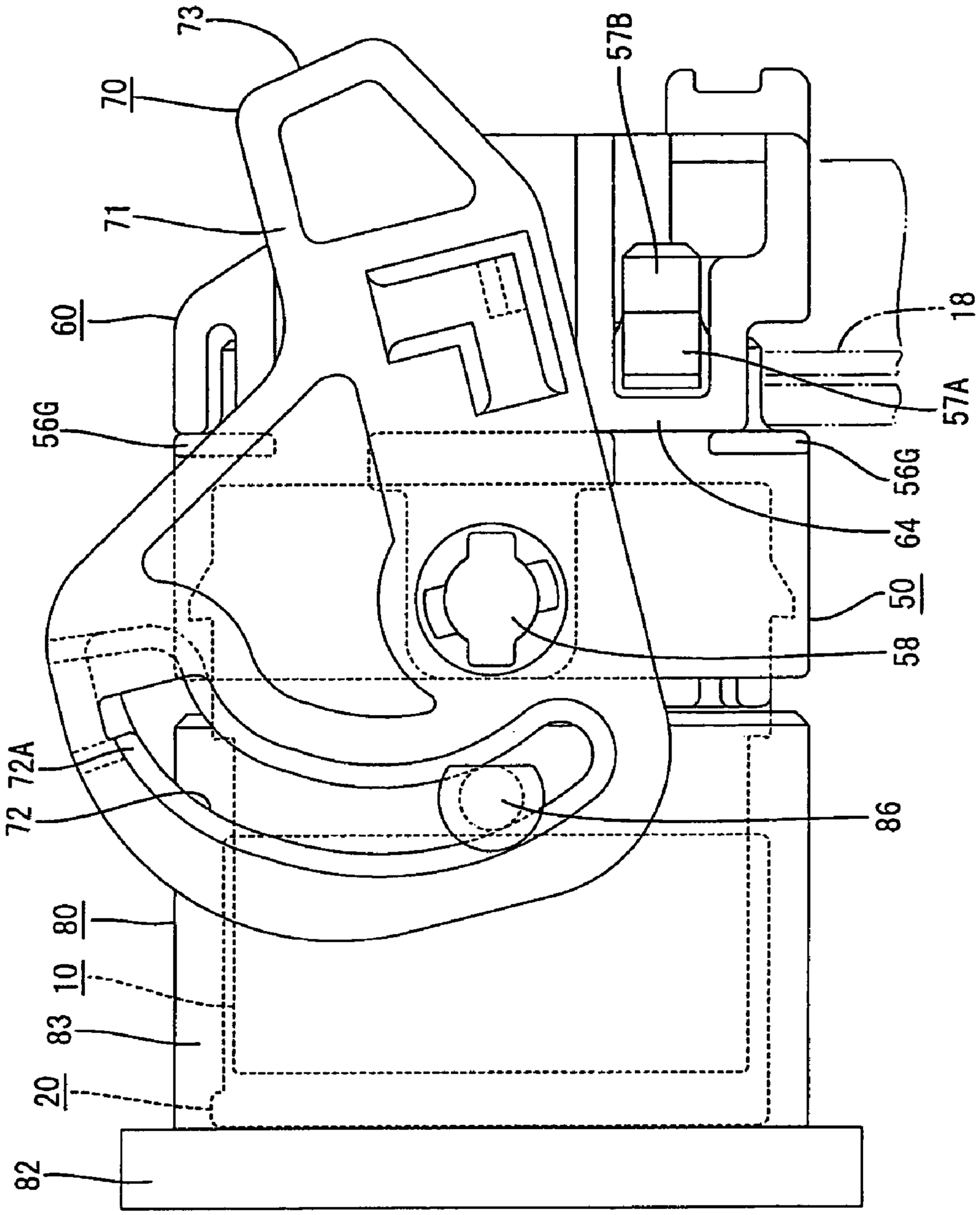
FIG. 2



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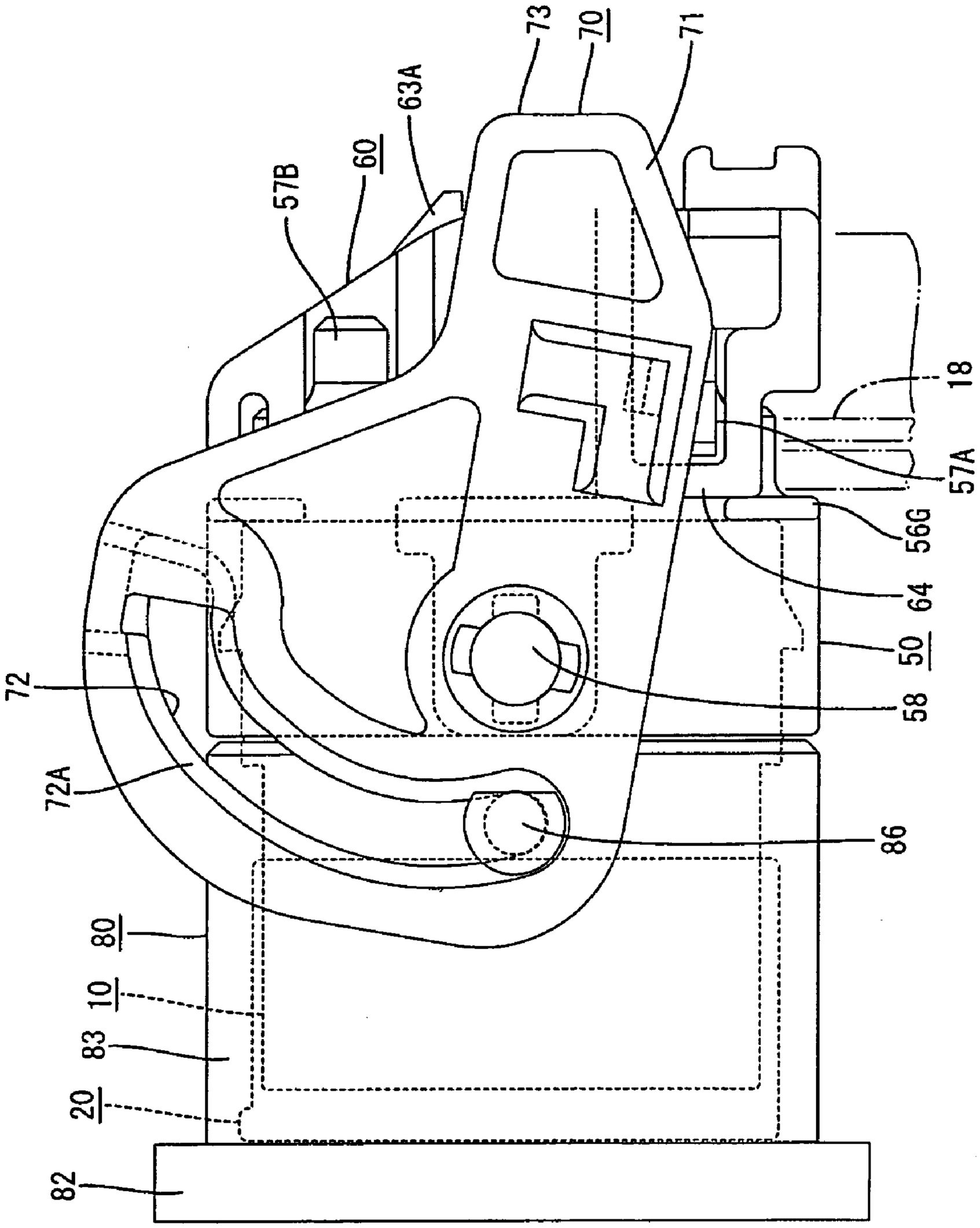

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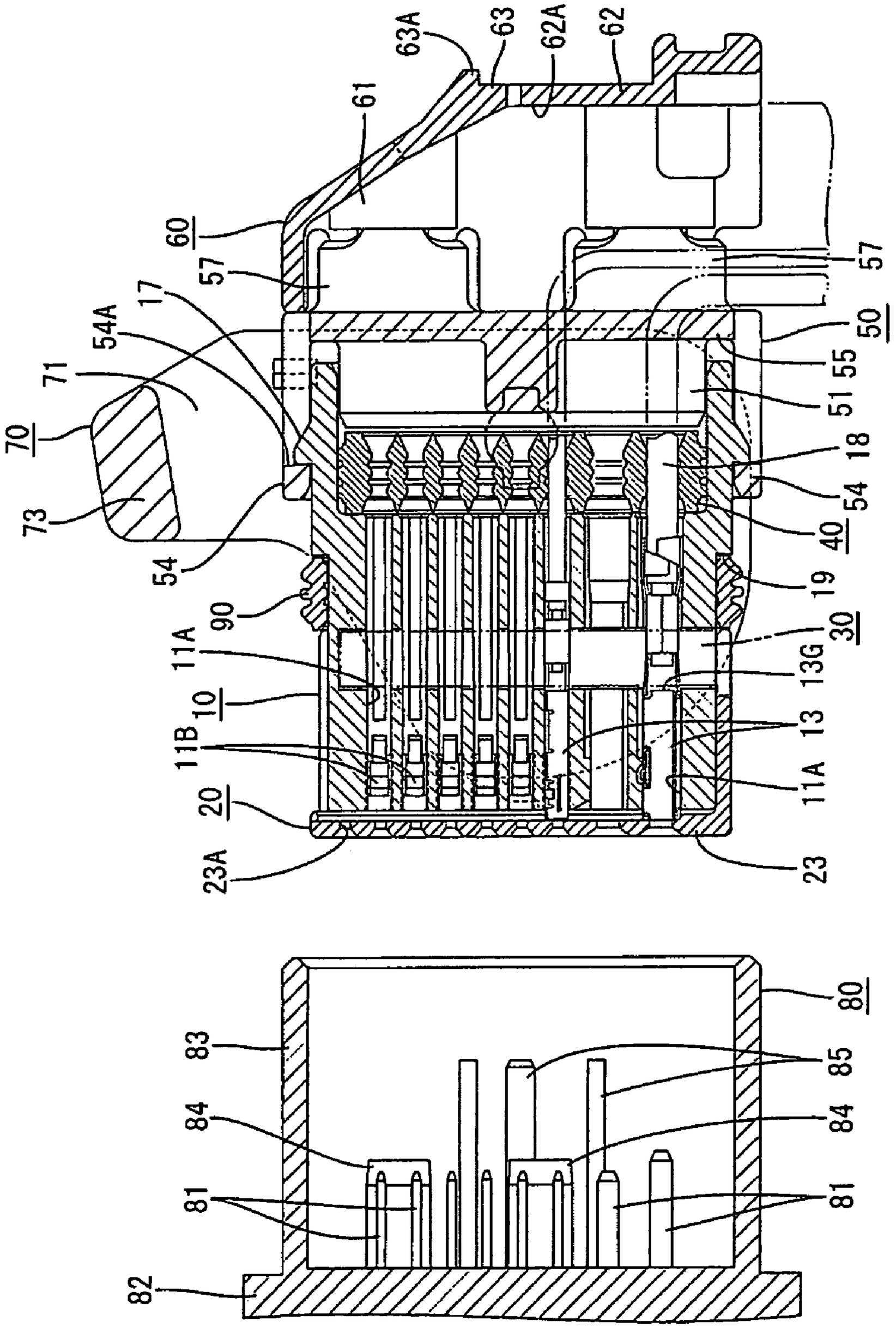
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FIG. 5

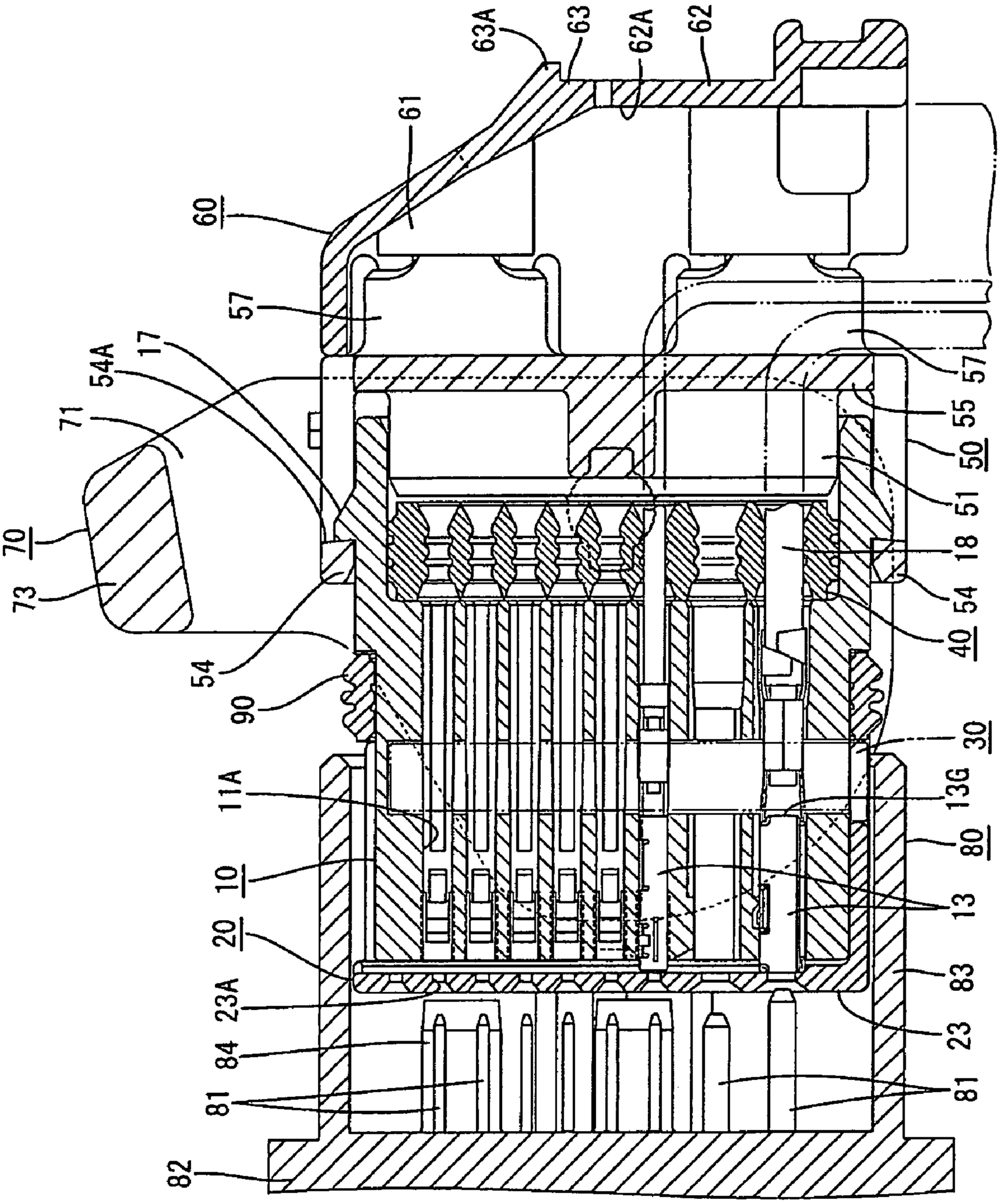
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FIG. 6

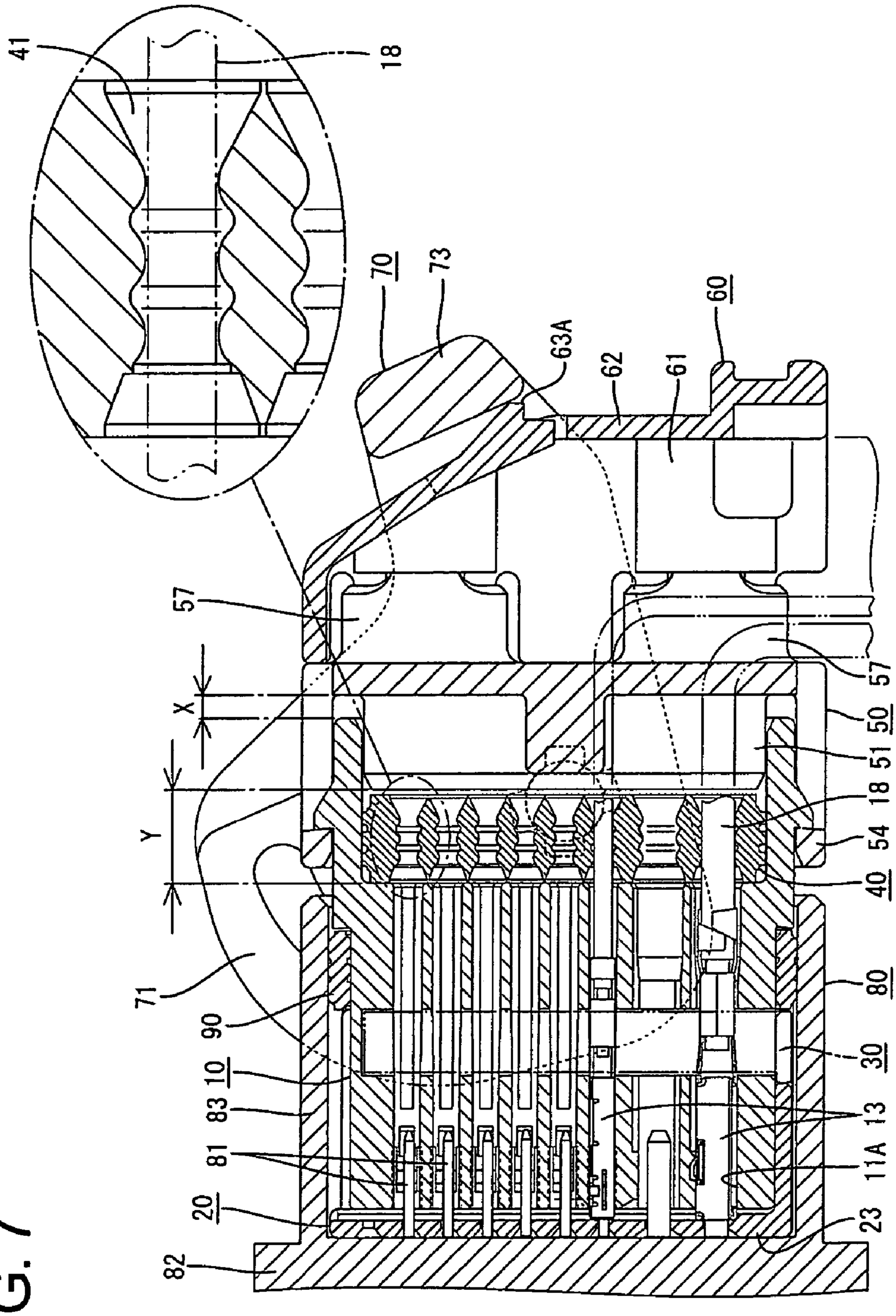
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FIG. 7

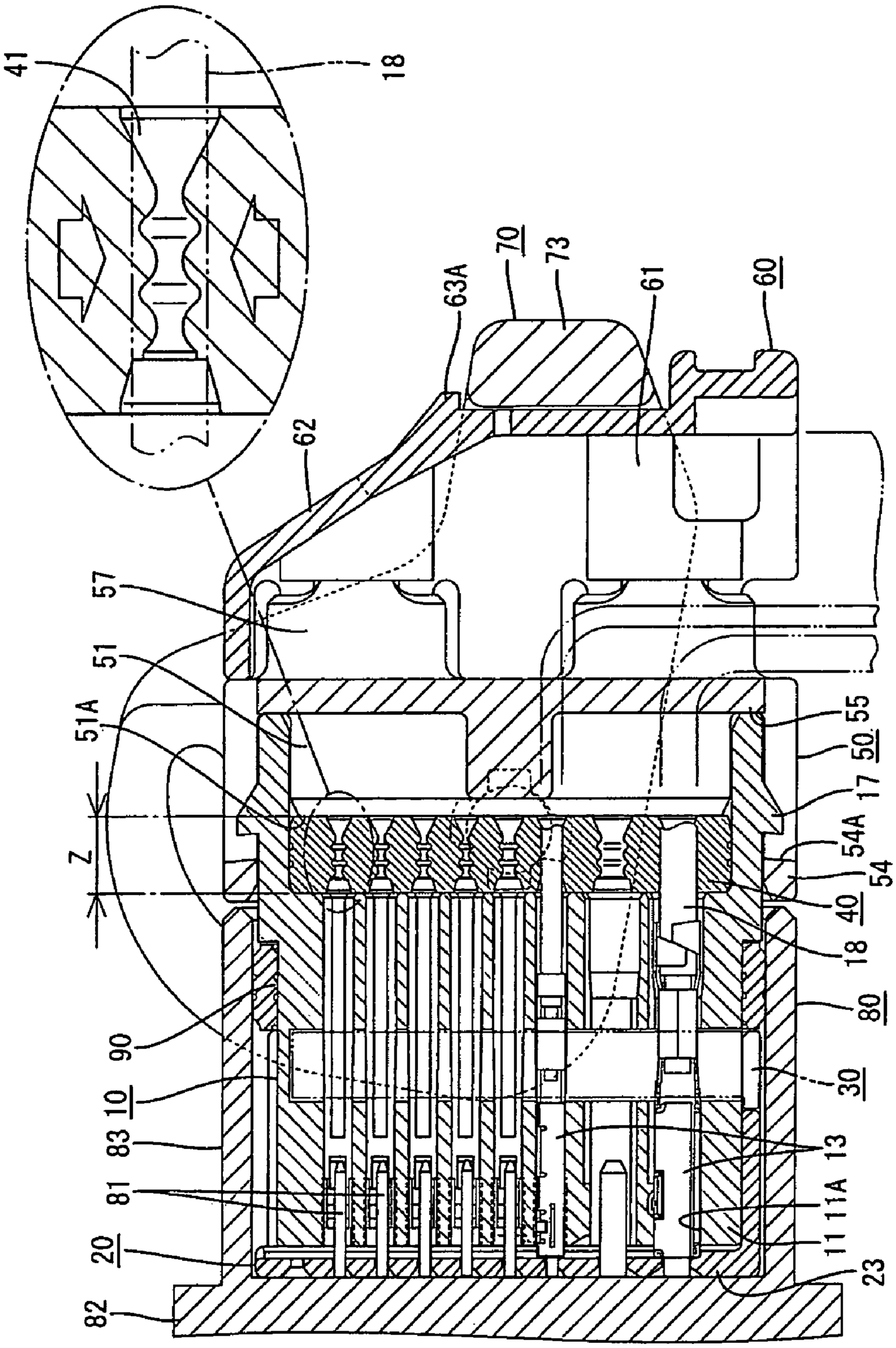
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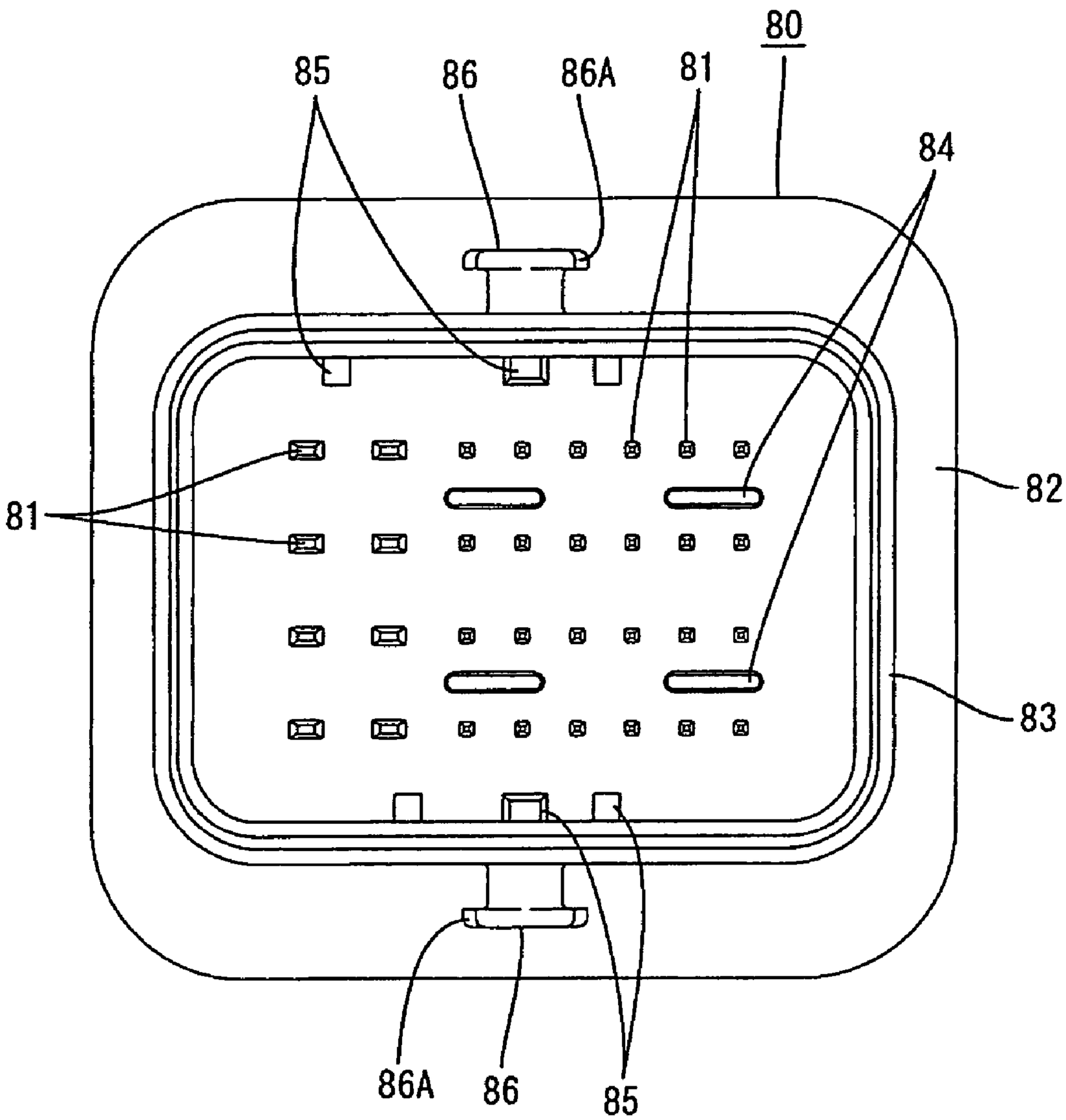
FIG. 8

FIG. 9



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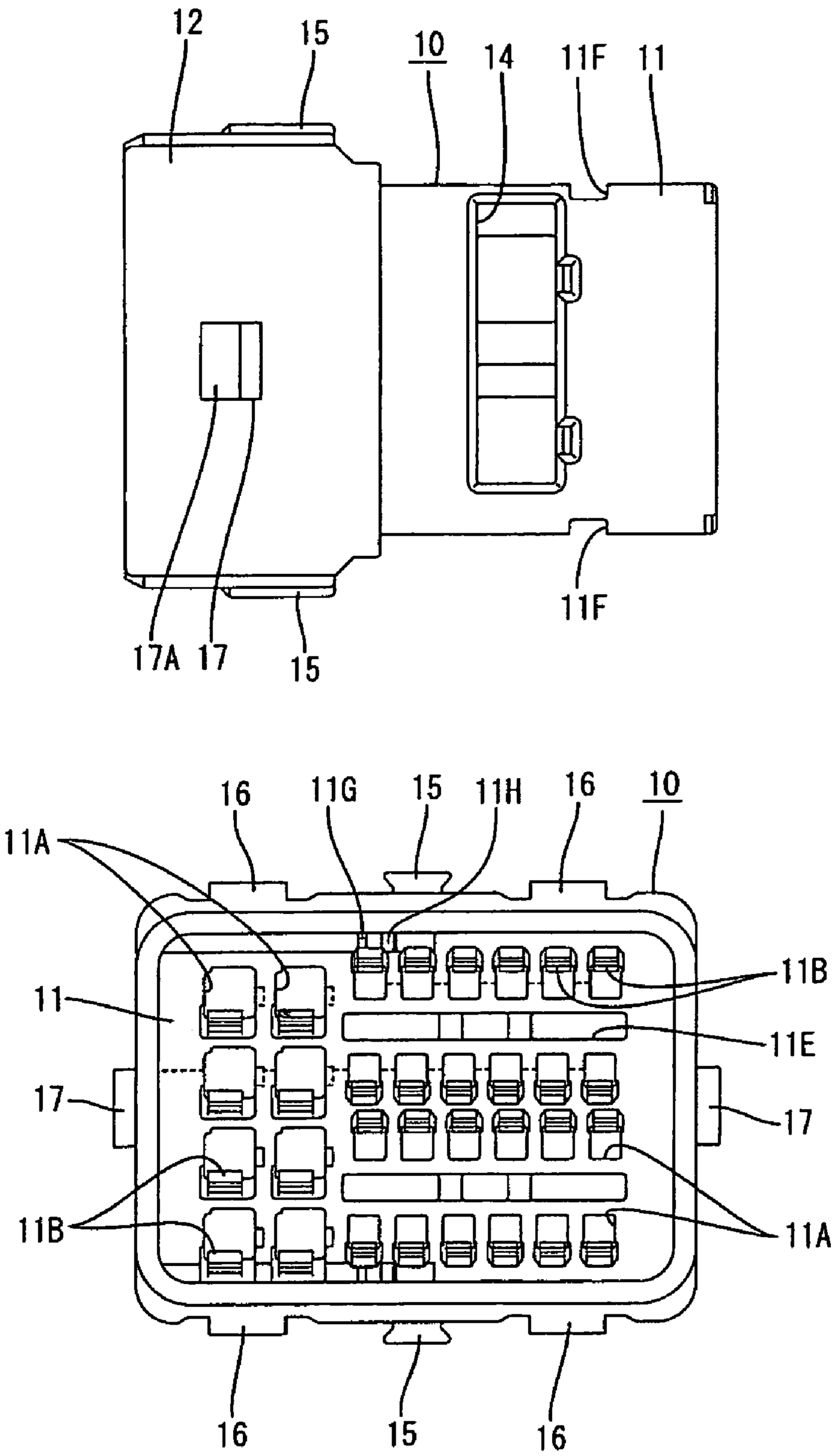
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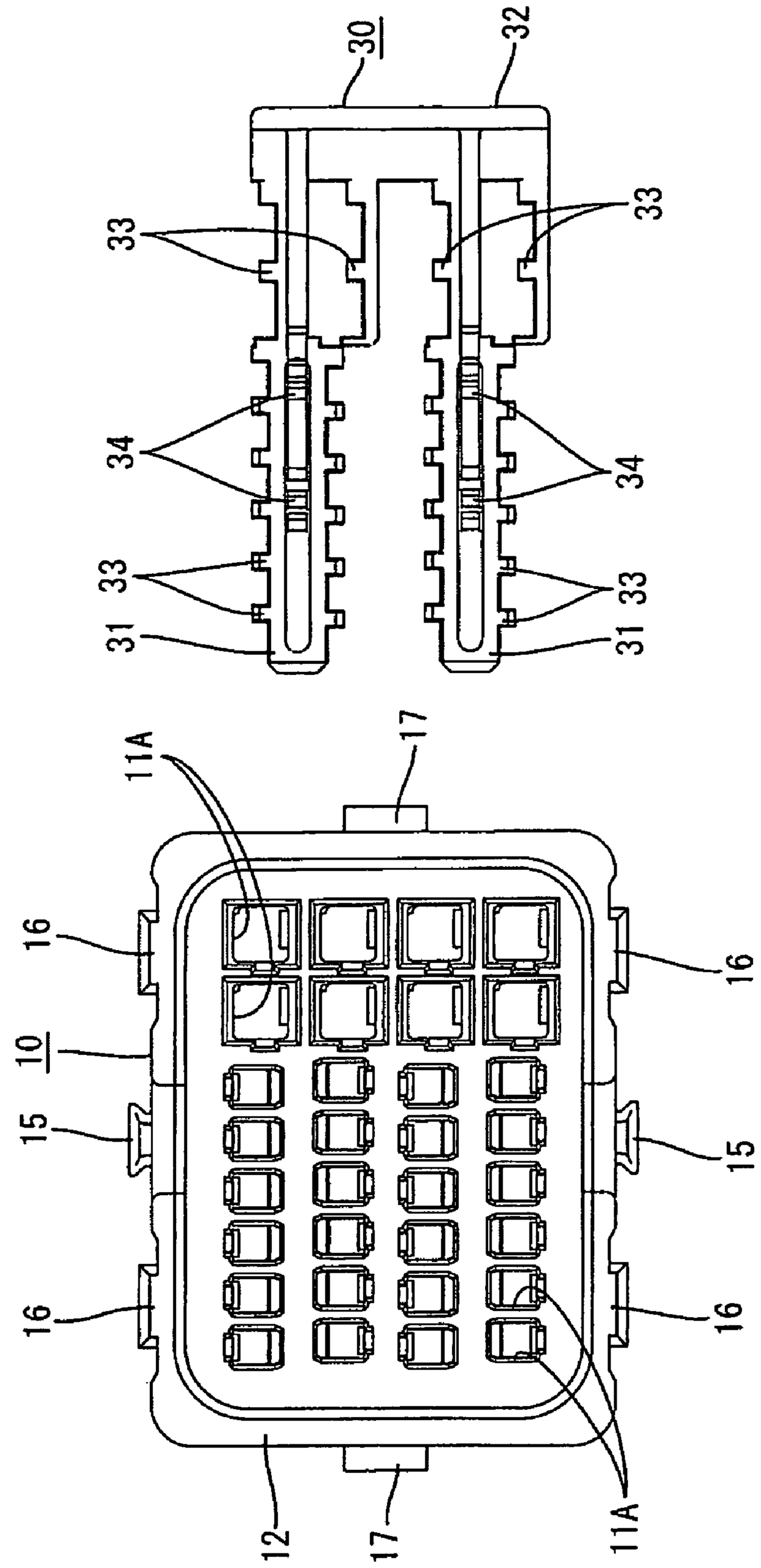
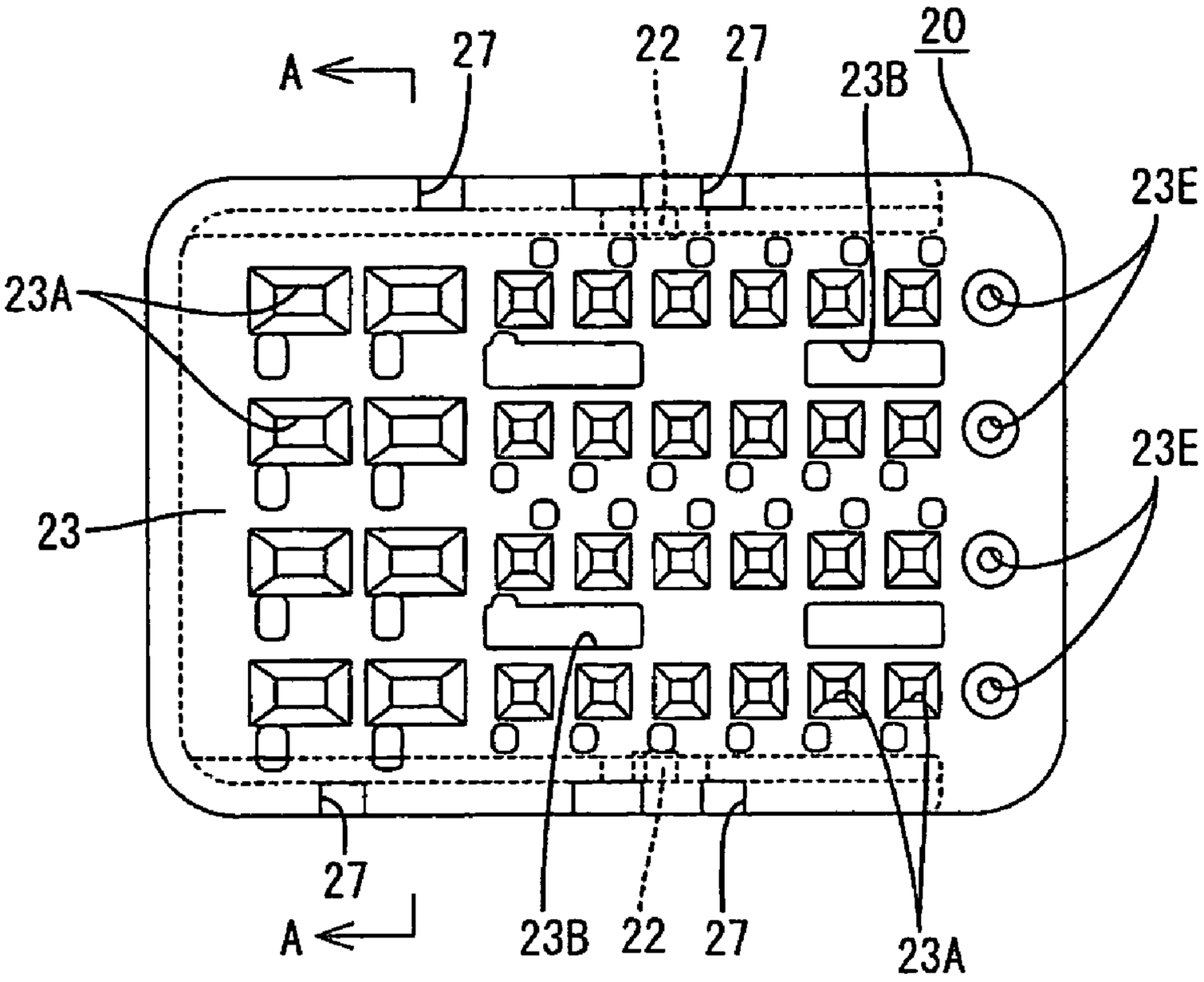


FIG. 11

FIG.12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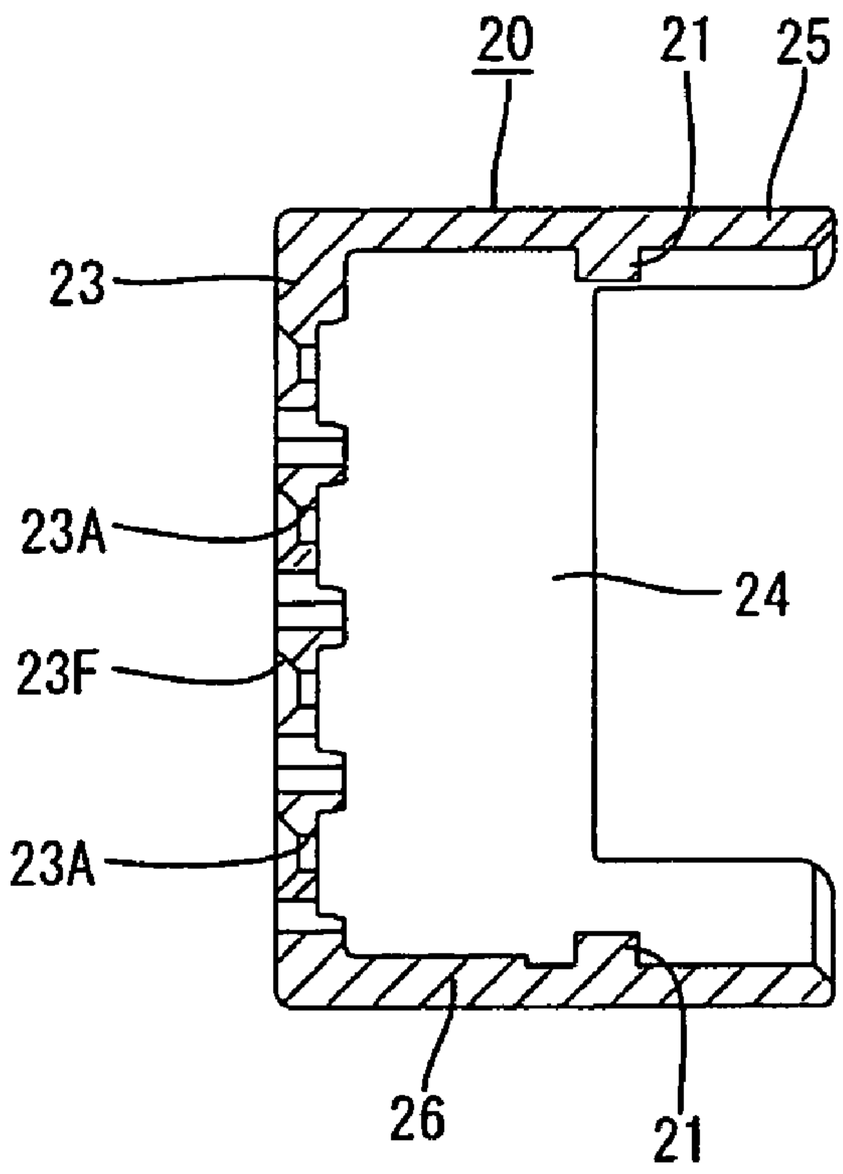
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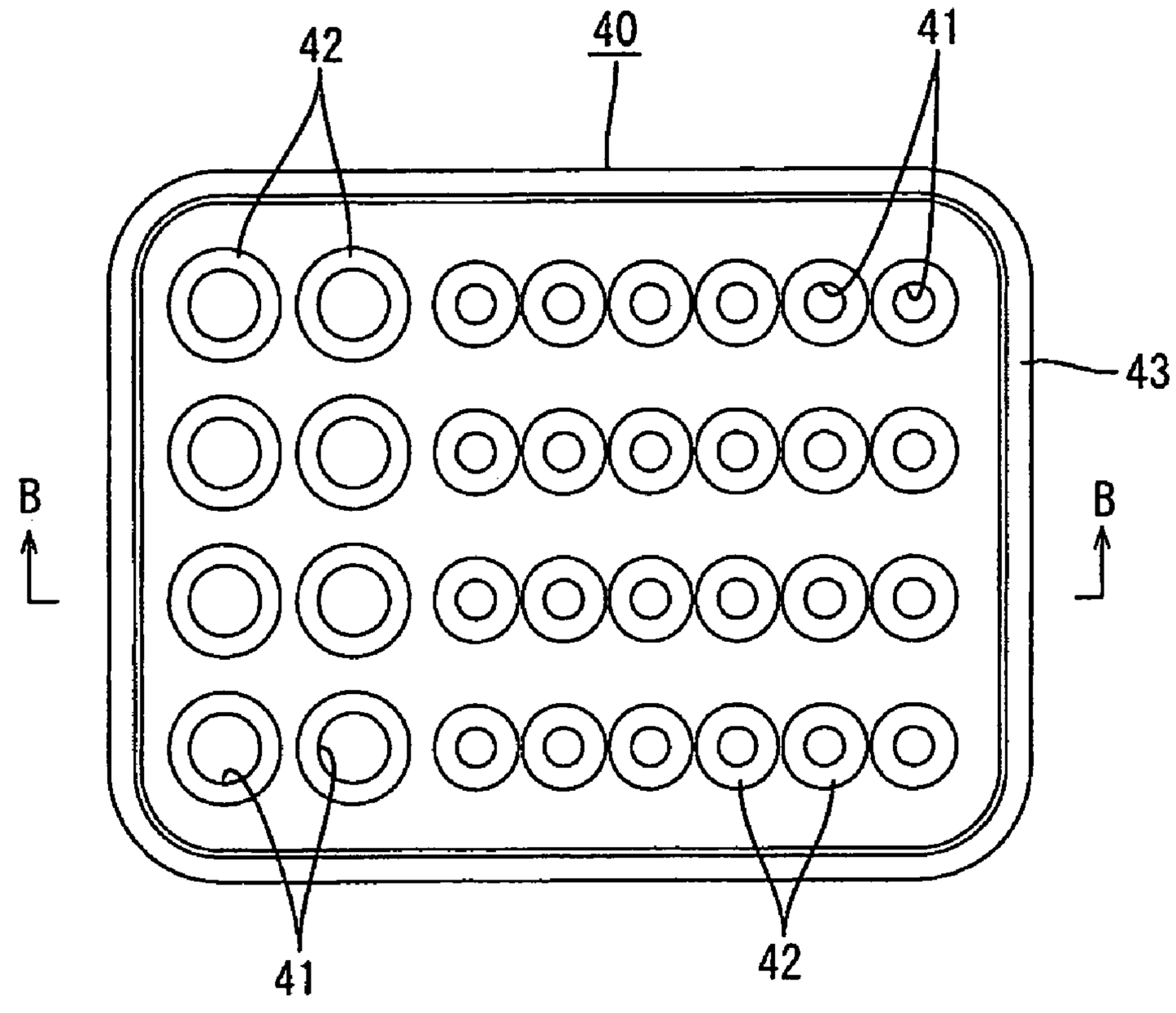

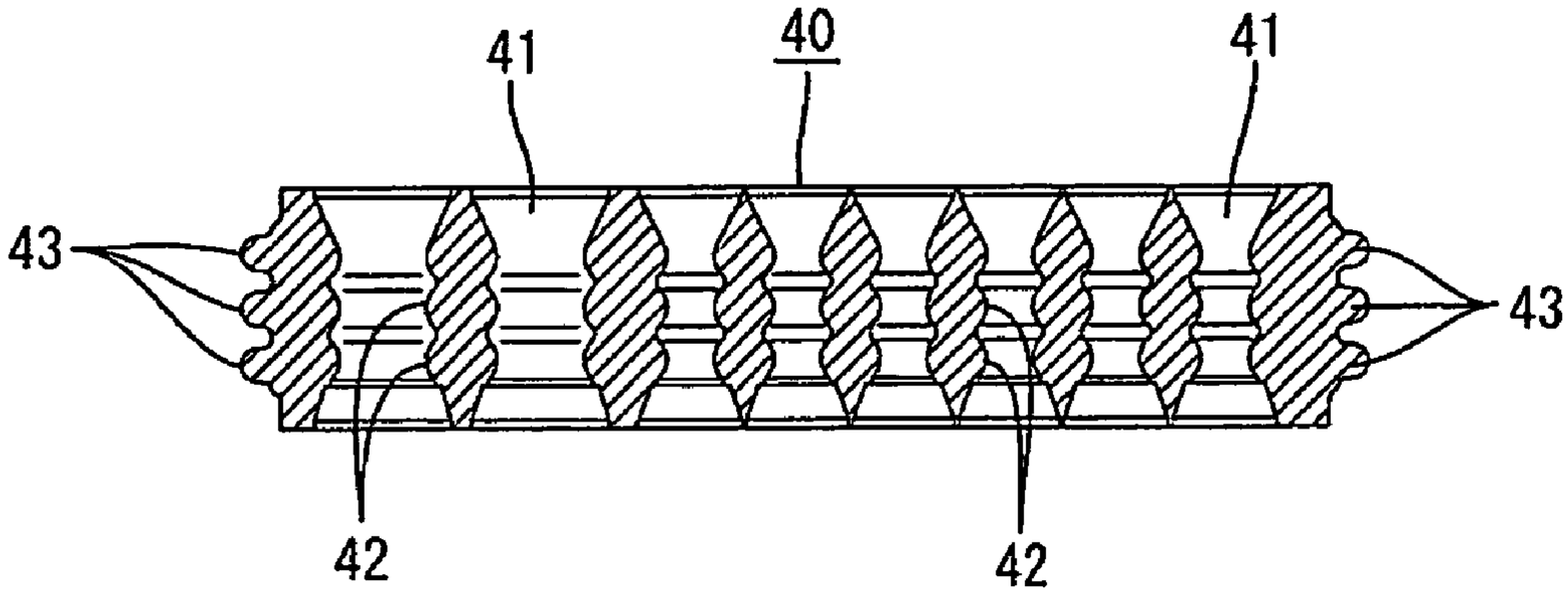

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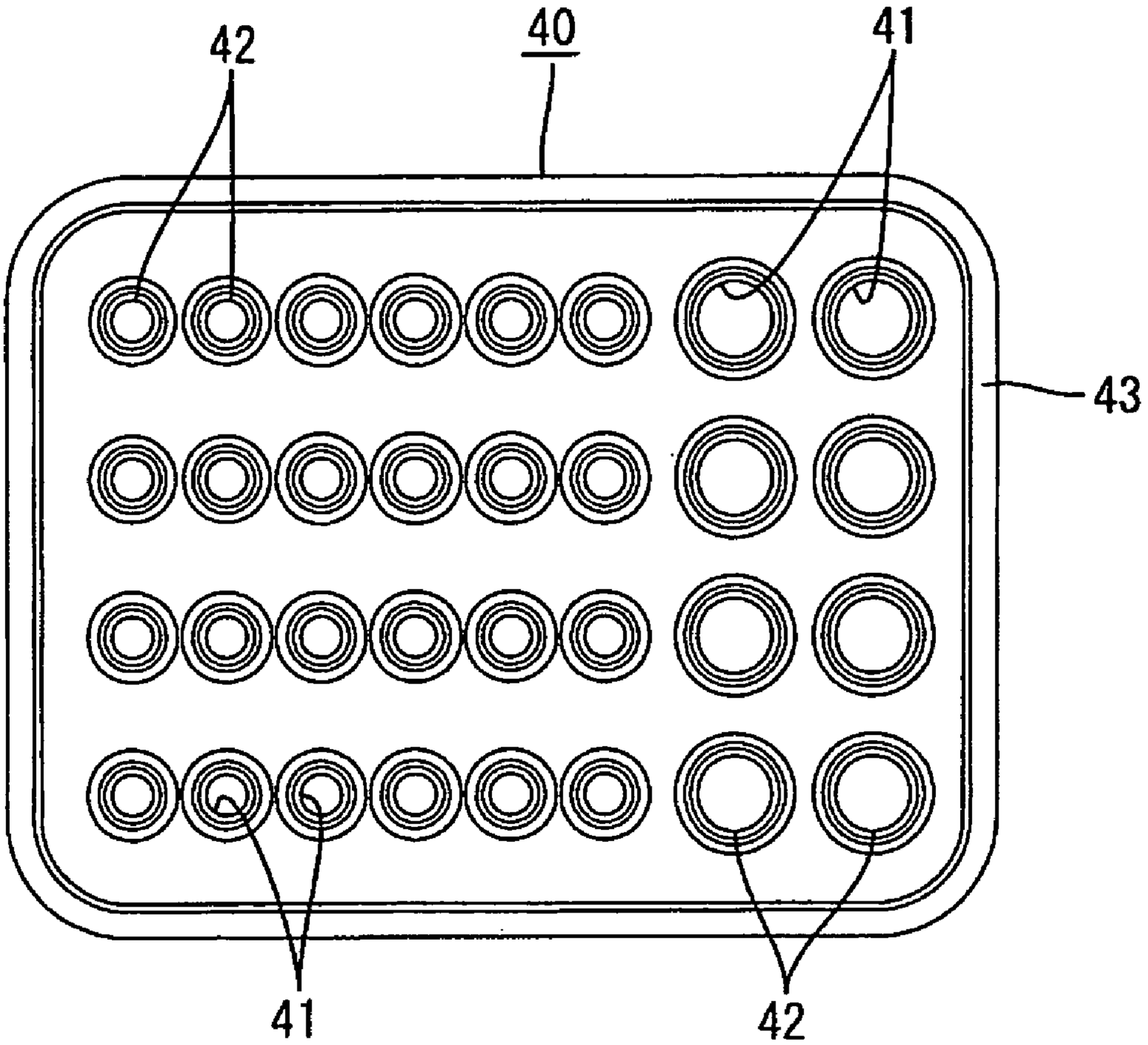

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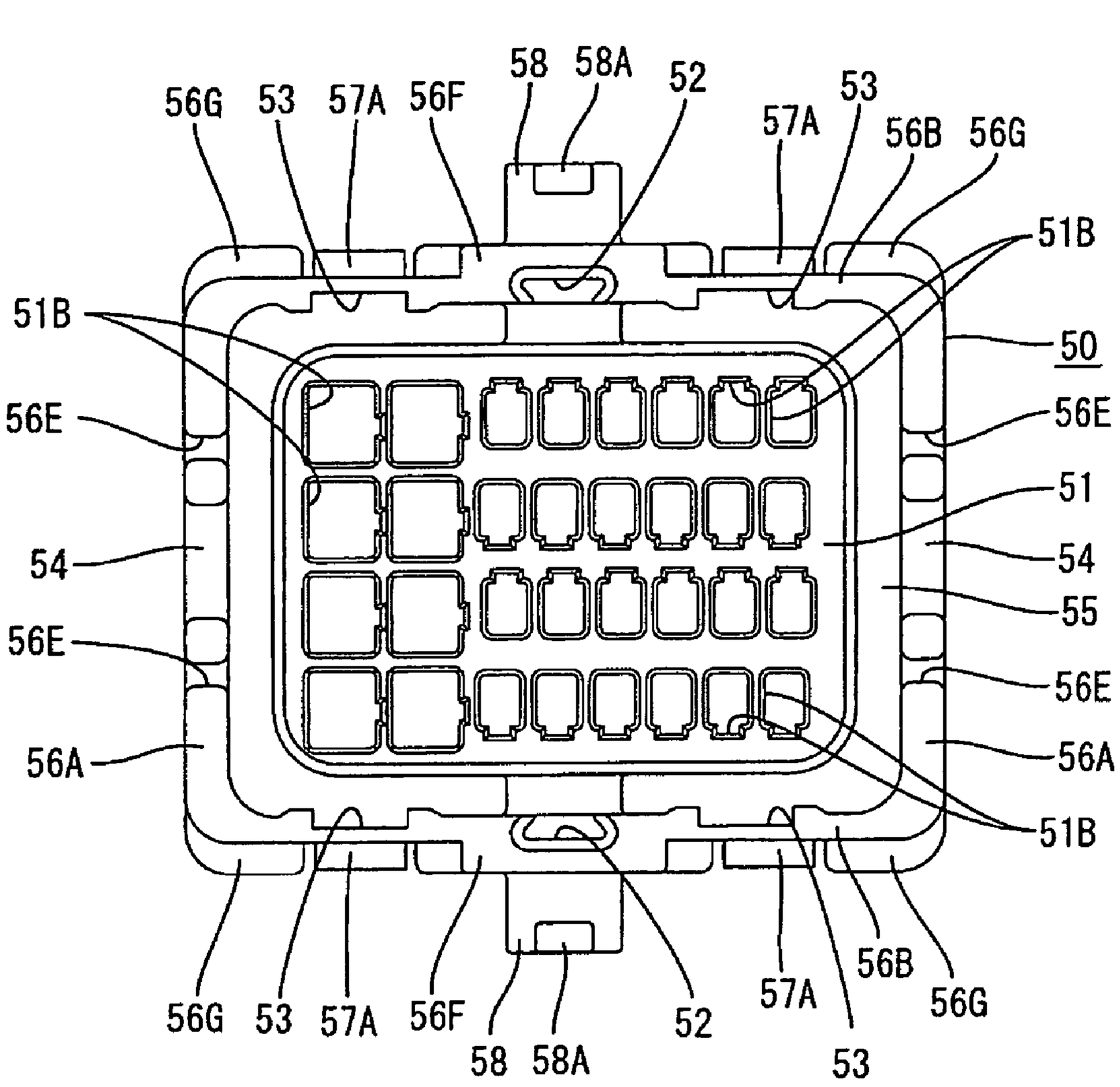
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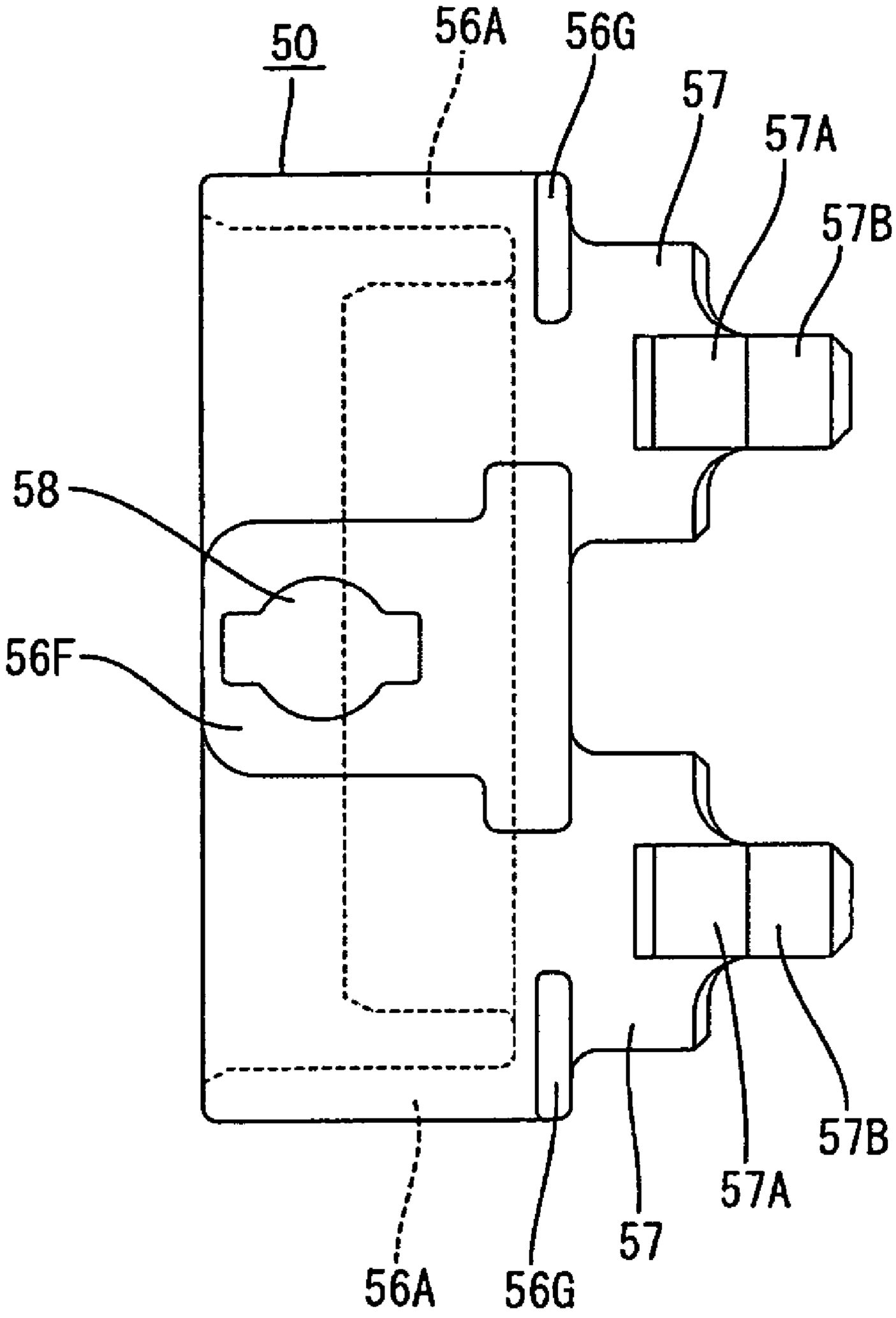
FIG. 16



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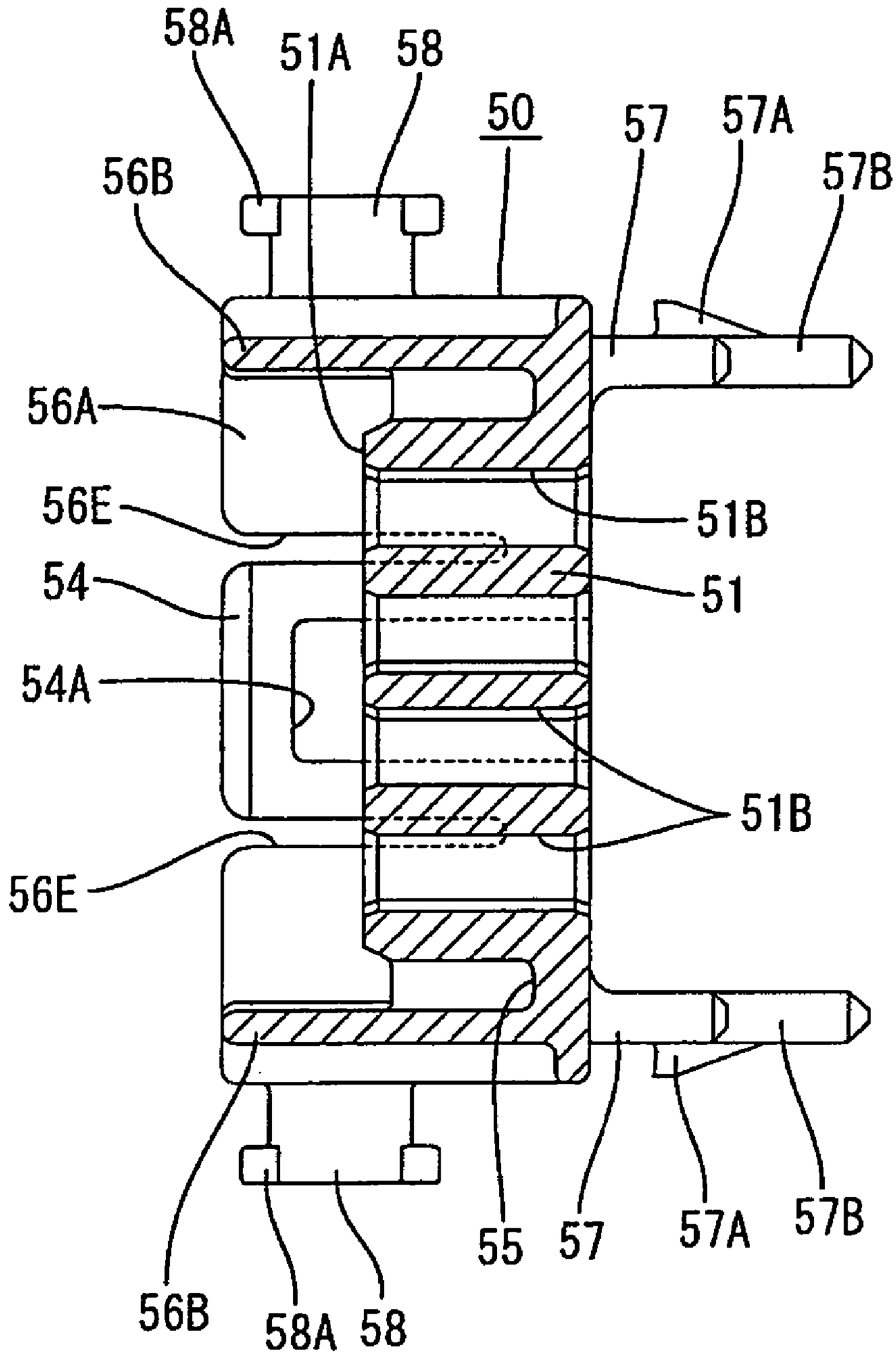
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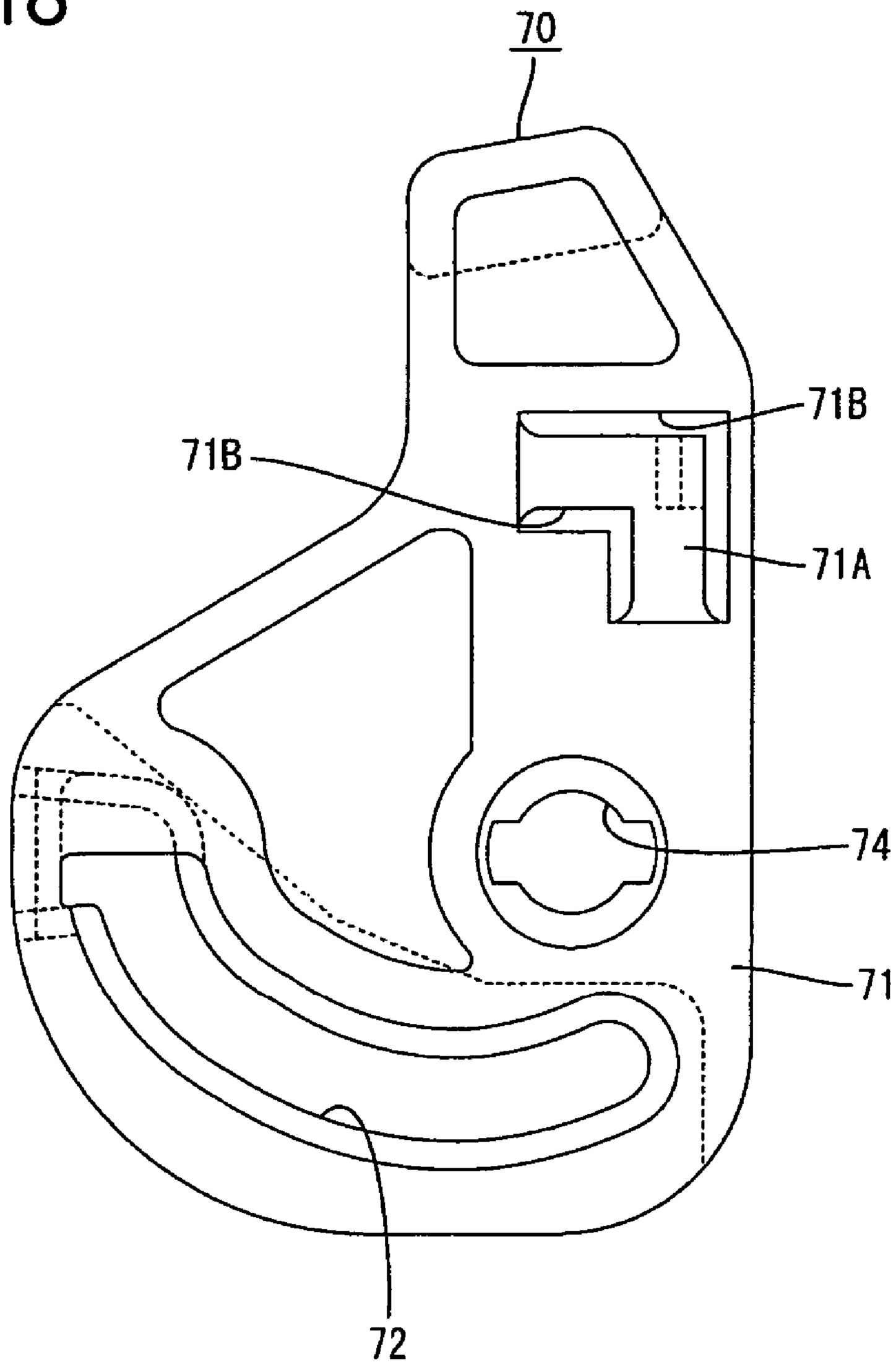
FIG. 18



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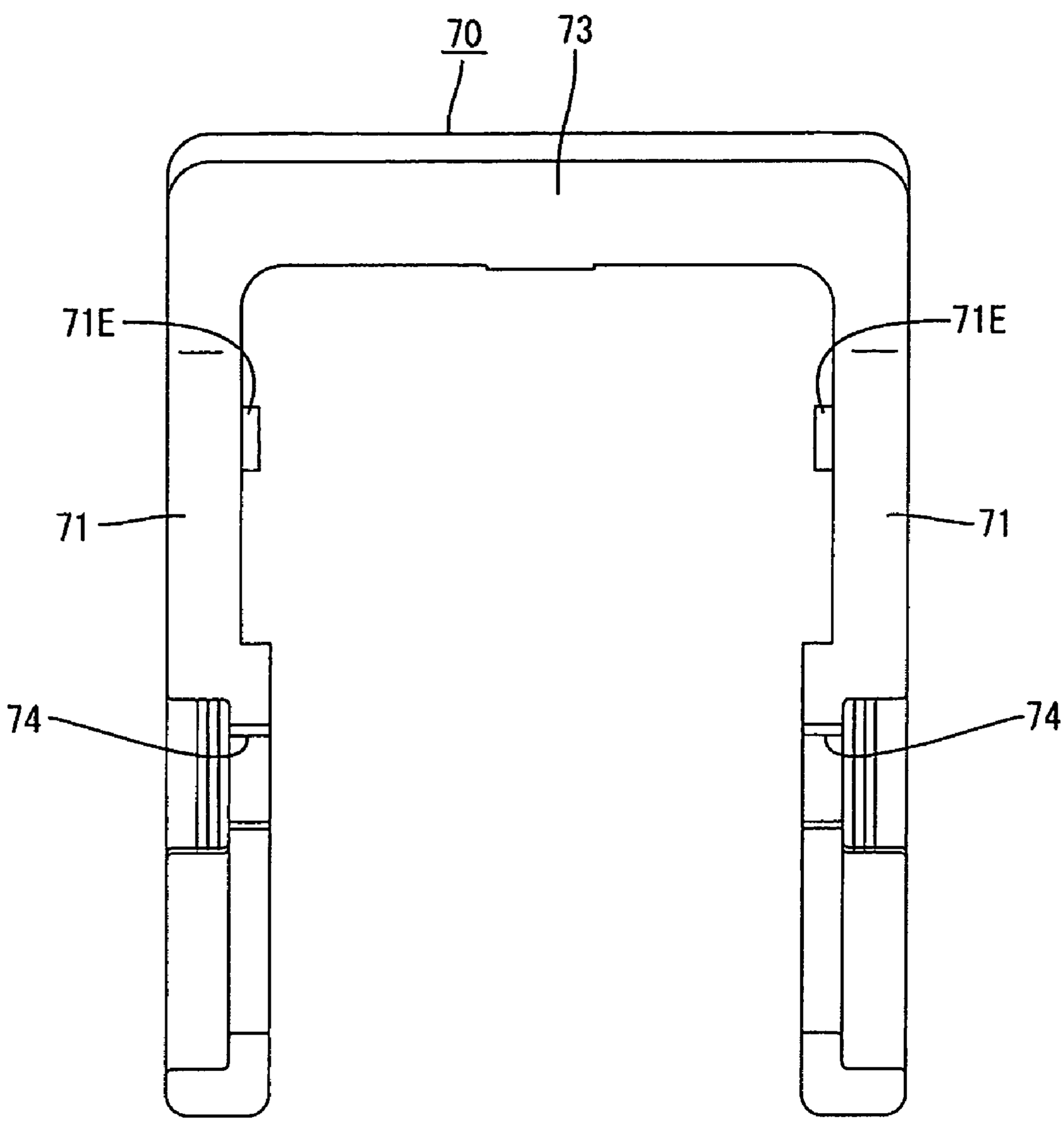

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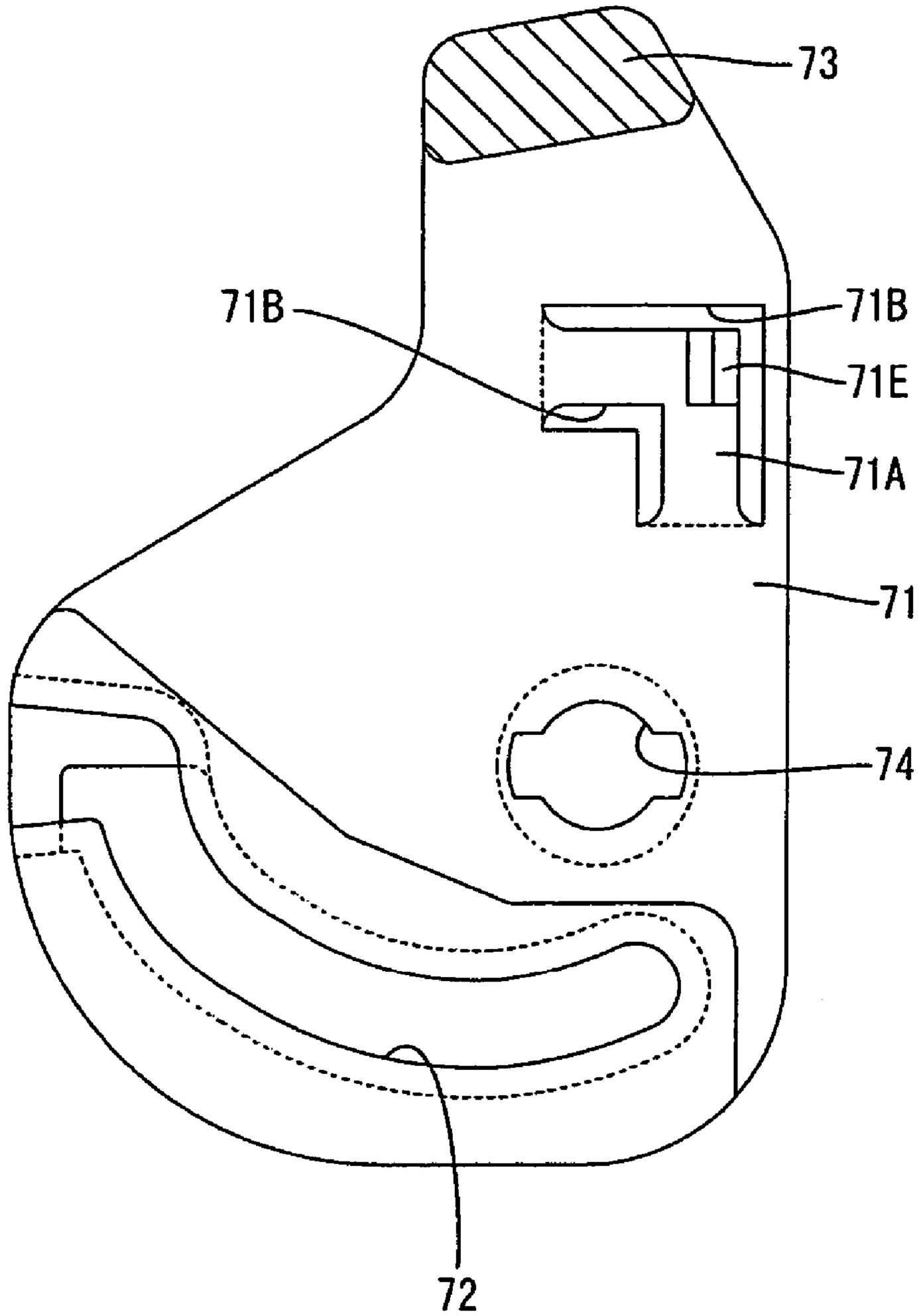

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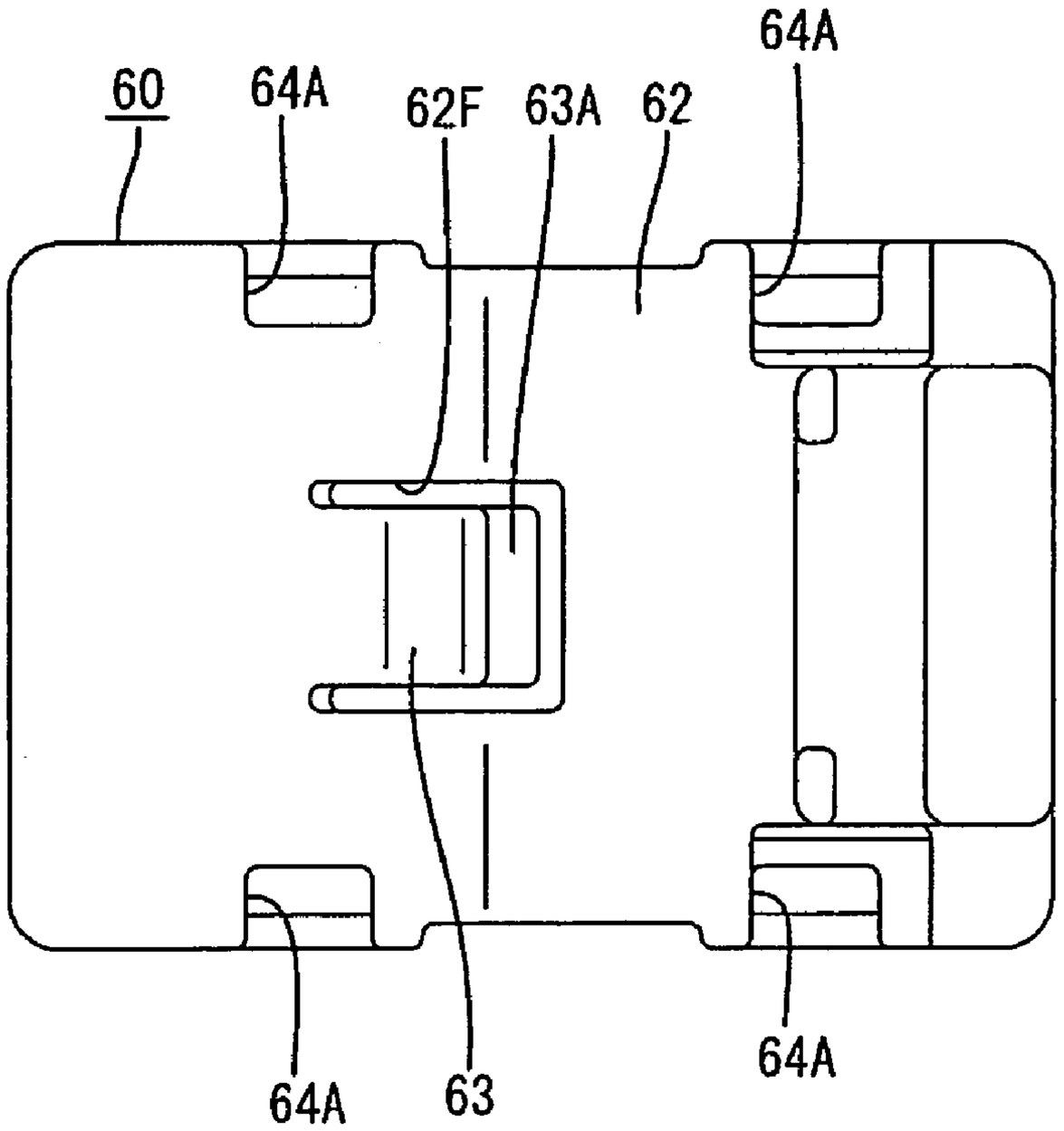

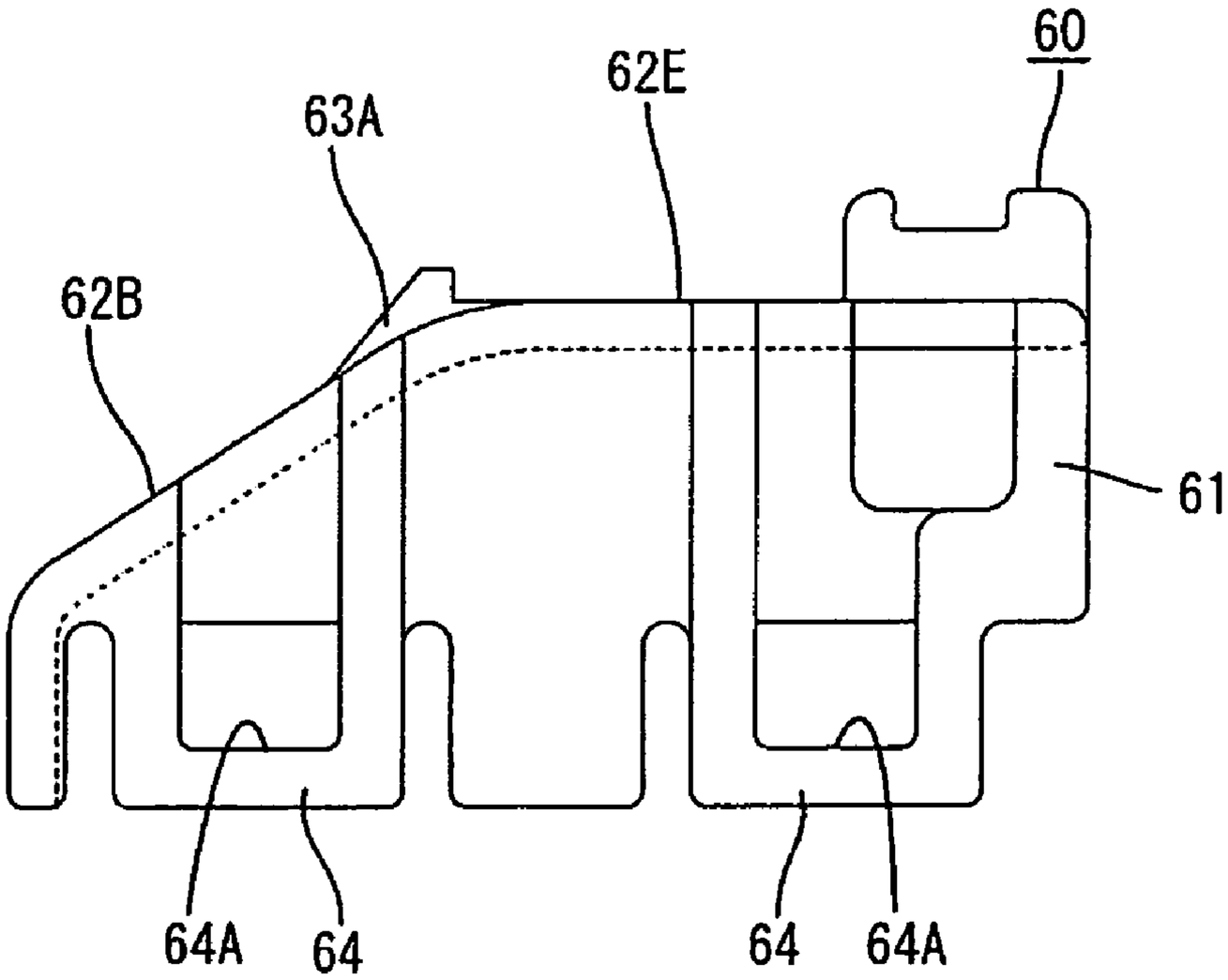

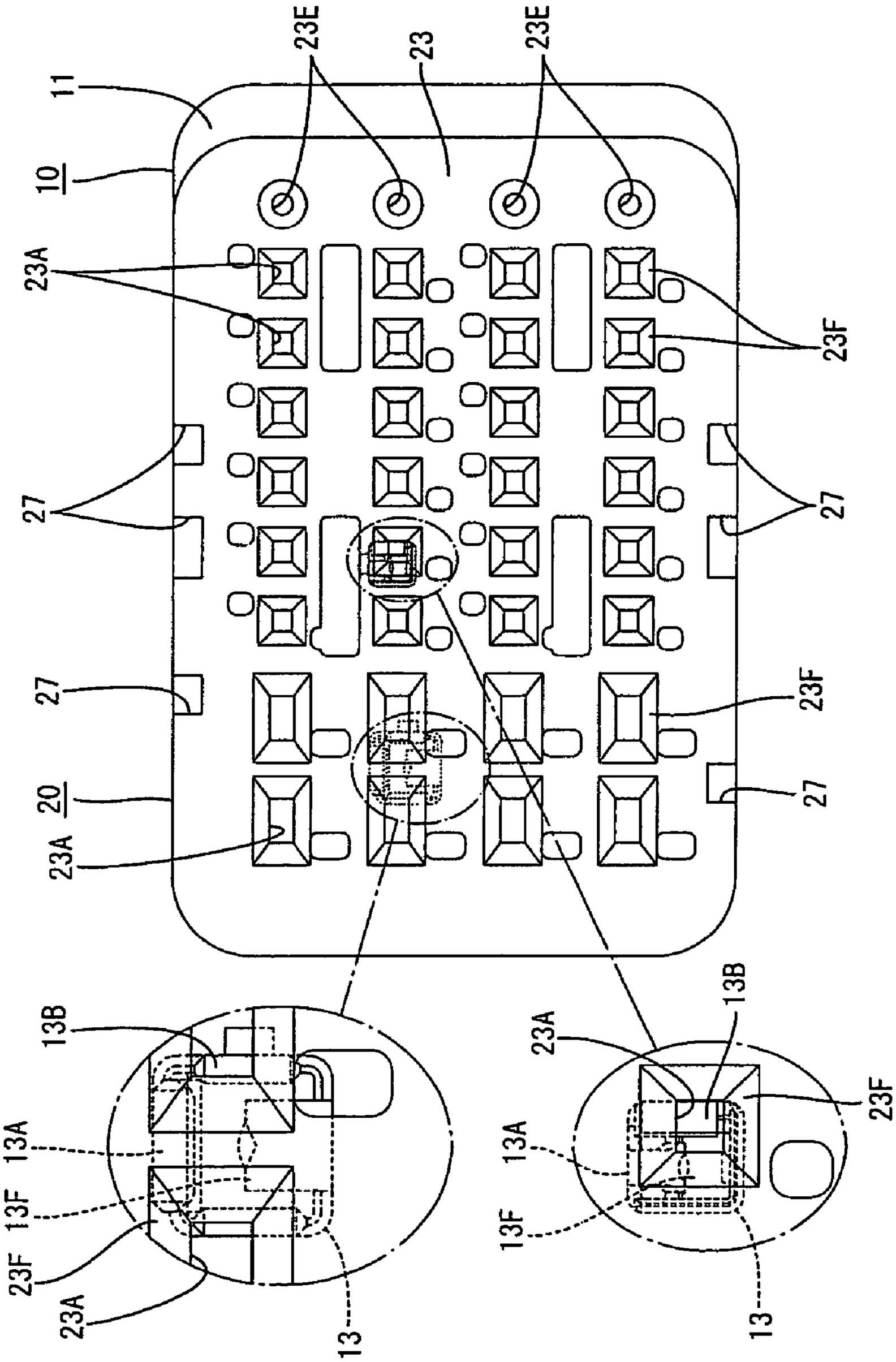
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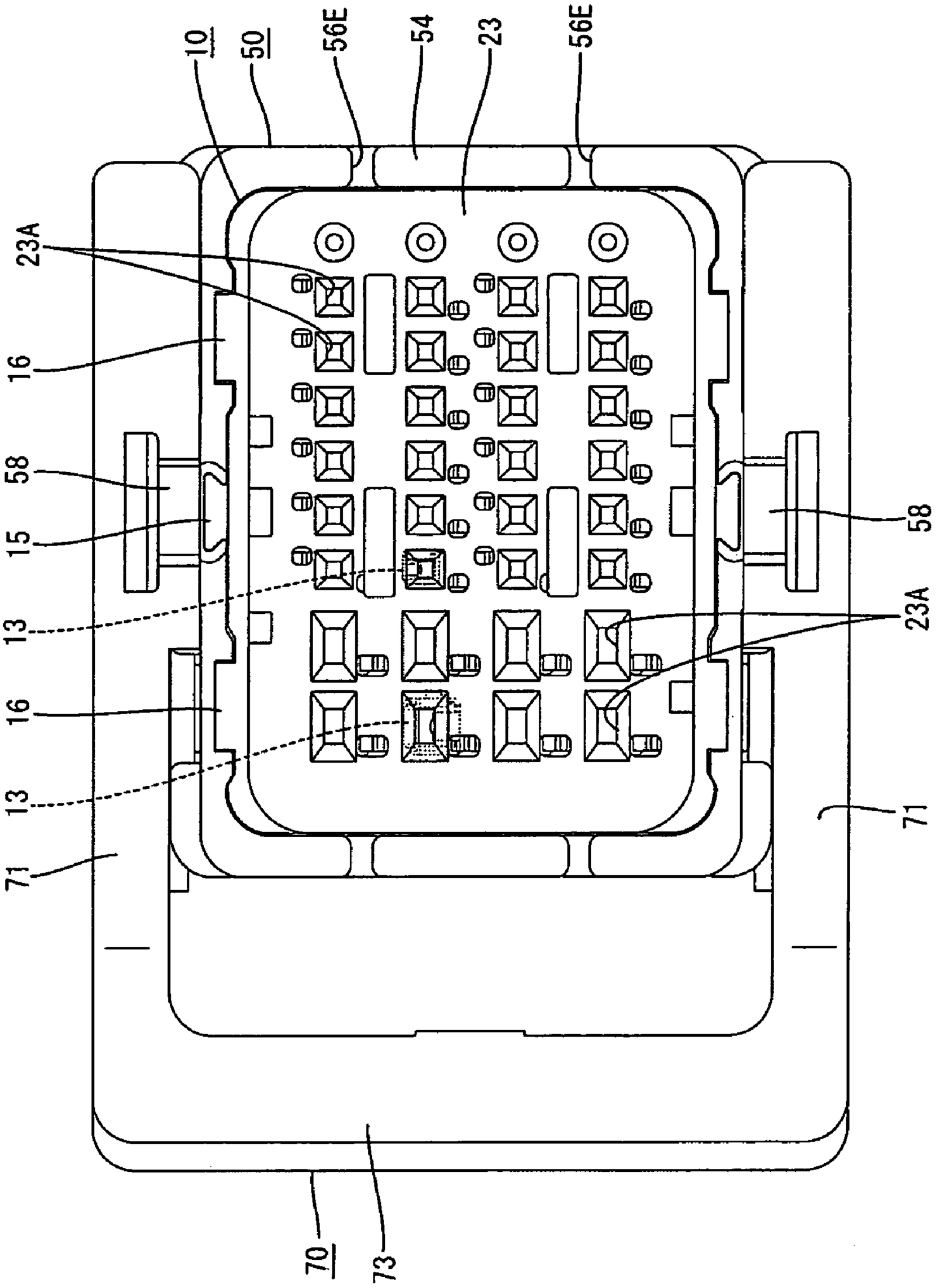
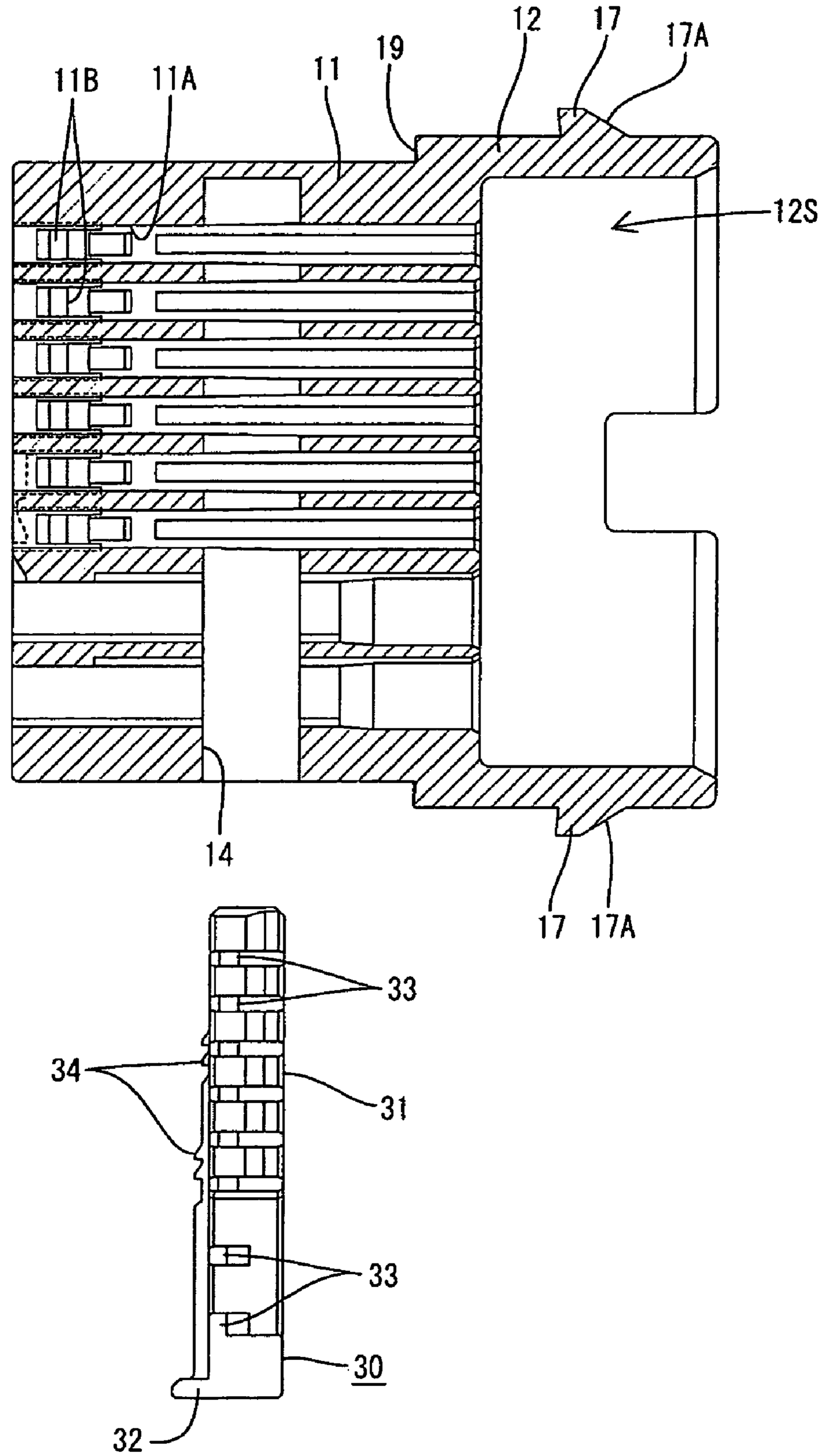


FIG. 23

FIG. 24



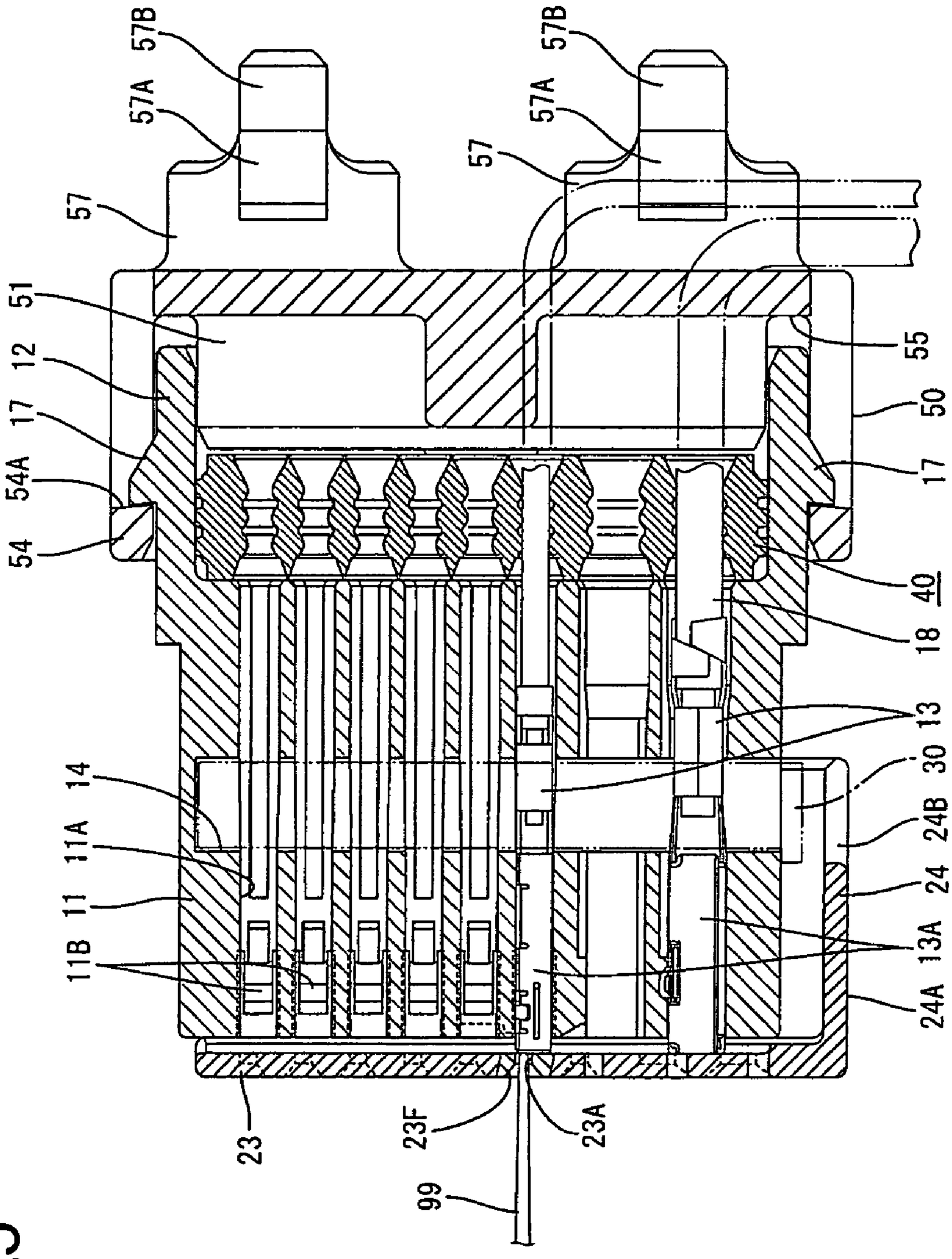

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FIG. 25

FIG. 26

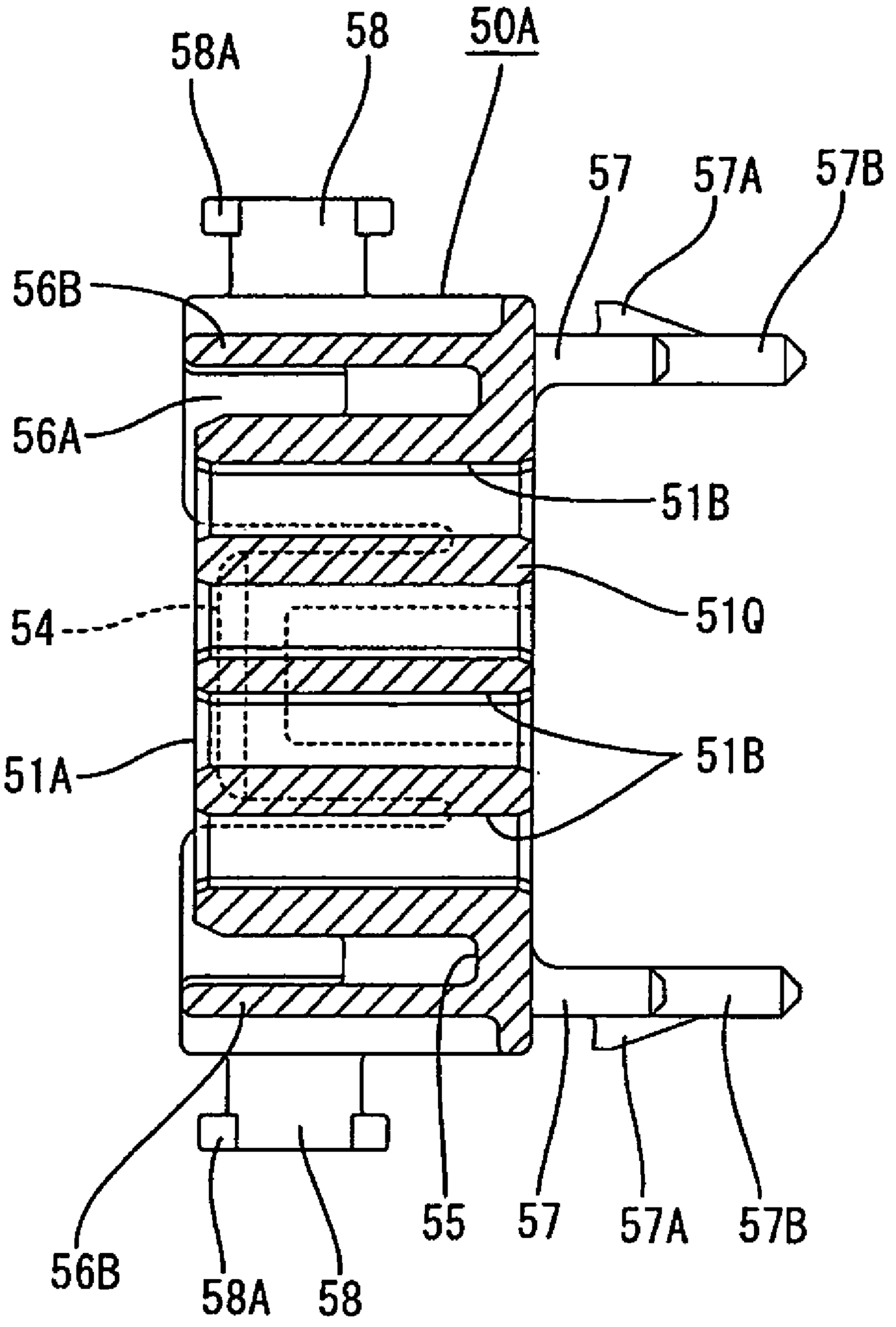
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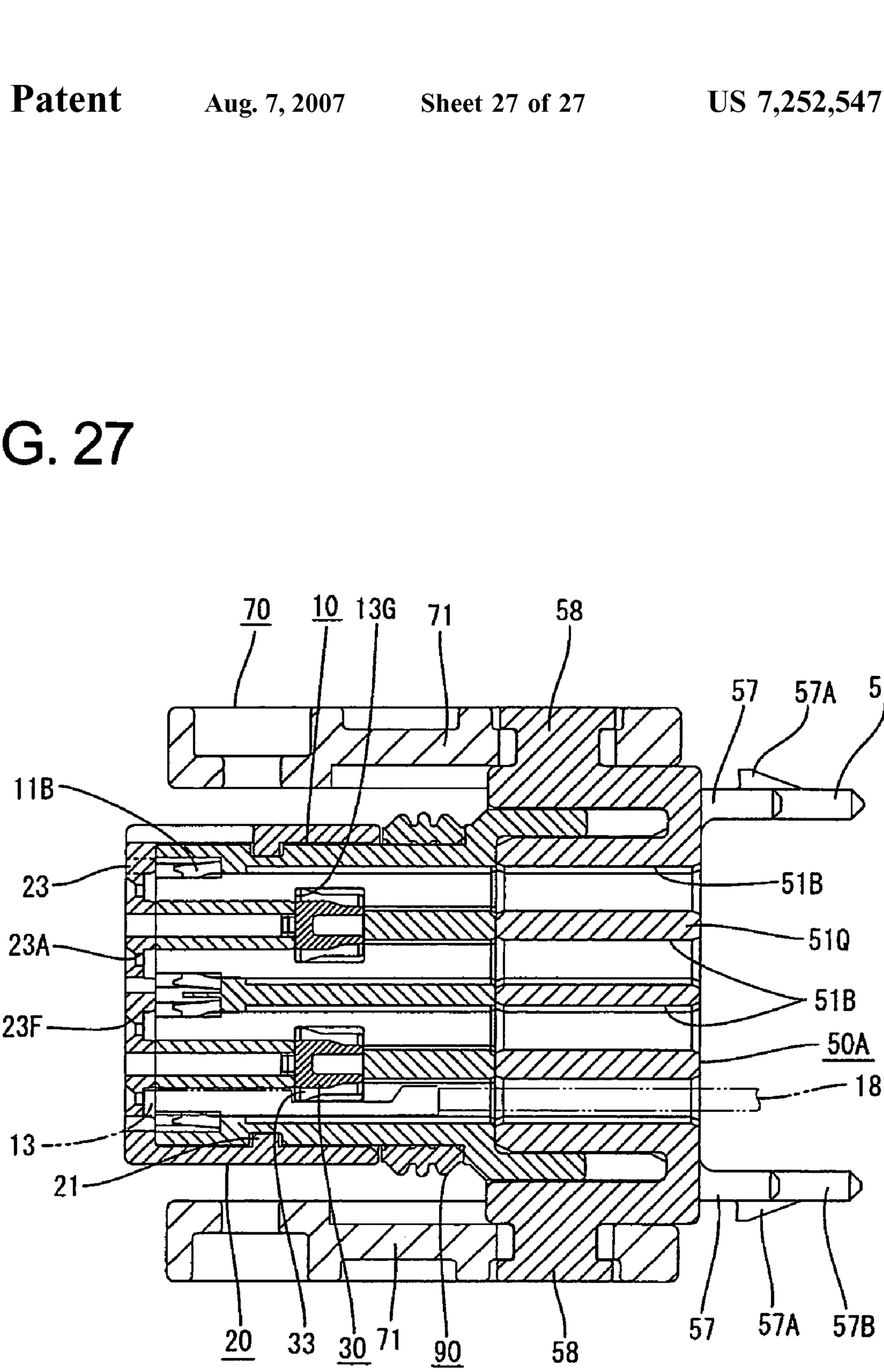
FIG. 27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CONNECTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a connector.

2. Description of the Related Art

Japanese Unexamined Patent Publication No. H10-3963 discloses a connector with a housing that has a terminal accommodating portion for accommodating terminal fittings. A sealing plug is fit into a plug mounting hole formed in the rear surface of the housing and a rear holder is attached to the rear surface of the sealing plug to prevent the sealing plug from coming out. Pivot shafts project from the opposite side surfaces of the housing and a lever is mounted rotatably on the shafts.

The housing has a complicated construction due to the terminal accommodating portion, the pivot shafts and the like. Thus, a complicated mold is required to form the housing.

Further, for the exchange of the lever, requires the uneconomical exchange of the housing.

The present invention was developed in view of the above problems, an object thereof is to simplify the construction of a mold for forming a connector housing and to make it, unnecessary to exchange the connector housing when exchanging a movable member.

SUMMARY OF THE INVENTION

The invention relates to a connector with a housing that has terminal accommodating chambers for accommodating terminal fittings. The connector also has a movable member for developing a cam action to connect the housing with a mating housing. A rear member is formed separately from the housing, but is mountable on a rear part of the housing. Insertion openings extend through the rear member, and the terminal fittings are insertable through the insertion openings in substantially the same direction as an inserting direction of the terminal fittings into the terminal accommodating chambers. The movable member is assembled directly or indirectly with the rear member. Thus, a construction necessary to assemble the movable member is on the rear member, and is separate from the housing. As a result, the mold for forming the housing can be simplified. Further, it is not necessary to exchange the housing when exchanging the movable member.

The movable member preferably is a lever displaying the cam action by guiding a cam pin on the mating housing along a cam groove in the lever.

An accommodation space is provided at the rear of the housing and has an inner peripheral sealing surface. A seal is accommodated in the accommodation space and closely contacts the sealing surface.

The seal preferably has wire insertion holes that normally are in a large-diameter state for receiving the terminal fittings and wires.

The rear member preferably is a rear holder with a pressing surface for pressing and holding the seal. The rear holder also has insertion openings for loosely receiving the terminal fittings and the wires.

The rear holder preferably compresses the seal in the thickness for narrowing the wire insertion holes. As a result, the inner surfaces of the wire insertion holes closely contact the wires. The pressing surface of the rear holder preferably compresses the seal after a connecting operation of the two housings is completed by operating the movable member.

The wire insertion holes of the seal are in the large-diameter state before the lever is rotated. Thus, the terminal fittings and the wires can be inserted easily through the insertion holes. The lever then is rotated to connect the housings and to move the rear holder forward after the housings are connected. The pressing surface of the rear holder compresses the seal as the rear holder moves forward. As a result, the wire insertion holes are deformed to smaller diameters and the inner circumferential surfaces of the wire insertion holes closely contact and seal to the wires.

The large diameters for the wire insertion holes can be set in correspondence with larger terminal fittings. Therefore, the inner circumferential surfaces of the wire insertion holes and the hole edges of the seal are not damaged as the terminal fittings are inserted.

The rear holder has a side that is displaceable along the outer peripheral surface of the rear part of the housing while the compression of the seal is in progress. Accordingly, a degree of compression of the seal can be confirmed visually by observing a moving stroke of the side of the rear holder.

In some instances, no seal is accommodated in the accommodation space. In these instances, a second rear member is provided and has a base that is fit in the accommodation space. The base of the second rear member has insertion paths corresponding to the terminal accommodating chambers.

The seal and the first of the above described rear members are selected if the connector must be watertight. However, the second rear member is selected if the connector need not be watertight. Accordingly, one of the first and second rear members is mounted on the housing depending on whether the connector must be watertight. Thus, the same housing can be used for both cases, and the number of parts is reduced.

These and other objects, features and advantages of the present invention will become more apparent upon reading of the following detailed description of preferred embodiments and accompanying drawings. It should be understood that even though embodiments are separately described, single features thereof may be combined to additional embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view showing a state before a female housing is connected with a mating male housing in a first embodiment.

FIG. **2** is a plan view showing a state where a lever is at a rotation starting position and cam pins are located at the entrances of cam grooves.

FIG. **3** is a plan view showing an intermediate state during the rotation of the lever.

FIG. **4** is a plan view showing the lever at a rotation ending position.

FIG. **5** is a horizontal section showing a state before the female housing is connected with the mating male housing.

FIG. **6** is a horizontal section of an intermediate state while the female housing and the mating male housing are brought closer to each other.

FIG. **7** is a horizontal section showing a state where the female housing and the mating male housing are properly connected.

FIG. **8** is a horizontal section showing a state where a sealing member is compressed by a pressing surface of a rear holder.

FIG. **9** is a front view of the mating male housing.

FIG. **10** is a right side view and a front view of the female housing.

FIG. **11** is rear views of a retainer and the female housing.

FIG. **12** is a front view and a section along A-A of the front view showing a front mask:

FIG. **13** is a front view and a section along B-B of the front view showing the seal.

FIG. **14** is a rear view of the sealing member.

FIG. **15** is a front view of the rear holder.

FIG. **16** is a plan view of the rear holder.

FIG. **17** is a side view in section of the rear holder.

FIG. **18** is a plan view of the lever.

FIG. **19** is a front view of the lever.

FIG. **20** is a horizontal section of the lever.

FIG. **21** is a plan view and a rear view of a wire cover.

FIG. **22** is a front view of the front mask at a partial locking position.

FIG. **23** is a front view of a connector.

FIG. **24** is horizontal section of the female housing and the retainer.

FIG. **25** is a horizontal section showing a state where an electrical connection test is conducted by inserting a jig through a tab insertion opening.

FIG. **26** is a side view in section of a rear member of a second embodiment.

FIG. **27** is a side view in section of a connector.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A connector in accordance with the invention is described with reference to FIGS. **1** to **25**. The connector has a female housing **10**, a front mask **20**, a retainer **30**, a seal **40**, a rear holder **50**, a lever **70**, and a wire cover **60**. The female housing **10** is connectable with a male housing **80** of a mating connector. Both female and male housings **10**, **80**, the front mask **20**, the retainer **30**, the rear holder **50**, the lever **70** and the wire cover **60** are made of synthetic resin, and the seal **40** preferably is made of a resilient material such as a rubber. In the following description, ends of the two housings **10**, **80** to be connected are referred to as front ends.

As shown in FIGS. **1** and **9**, the mating male housing **80** has a terminal mounting portion **82** in which tabs **81** of male terminal fittings with forwardly projecting tabs **81**. More particularly, the male housing **80** has a terminal mounting portion **82** for receiving the male terminal fittings. A rectangular tubular receptacle **83** projects forward from the front surface of the terminal mounting portion **82**, and the tabs **81** project forward in the receptacle **83**. The tabs **81** are aligned in rows and the dimensions of the tabs **81** substantially correspond to amounts of current flowing therethrough. The tabs **81** in the two rows at the right are wider than those in six rows at the left. Error-assembling preventing ribs **84** also project in the receptacle **83**. The error-assembling preventing ribs **84** interfere with the front surface of the female housing **10** when one of the two housings **10**, **80** is held in an improper orientation (such as upside down) with respect to the other and hinder any further connecting of the two housings **10**, **80**.

The female housing **10** is fittable into the receptacle **83**, and guiding ribs **85** extend in substantially forward and backward directions on the inner peripheral surface of the receptacle **83** for guiding the connecting operation with the female housing **10**. Upper and lower cam pins **86** project at positions near the front ends of substantially widthwise middle parts of the upper and lower outer surfaces of the receptacle **83**. Each cam pin **86** has a substantially cylindrical shape with a large-diameter flange **86**A at its projecting end, and is movable substantially along a corresponding cam groove **72** formed in a side plate **71** of the lever **70**.

As shown in FIGS. **10** and **11**, the female housing **10** has a substantially rectangular block shaped terminal accommodating portion **11** formed with terminal accommodating chambers **11**A. A fittable tube **12** projects back from the rear surface of the terminal accommodating portion **11** and defines a substantially rectangular tube that is larger than the terminal accommodating portion **11** and. The terminal accommodating portion **11** preferably takes up more than about half, more preferably almost two-thirds of the length of the female housing **10**, and the fittable tube **12** preferably takes up less than about half, more preferably the remaining one-third.

Female terminal fittings **13** are inserted into the terminal accommodating chambers **11**A from behind, and engage resilient locks **11**B that project from the inner peripheral surfaces of the terminal accommodating chambers **11**A (see FIG. **25**). The female terminal fittings **13** in the terminal accommodating chambers **11**A aligned in two rows at the right side of the terminal accommodating portion **11** have large box portions **13**A, whereas those in the terminal accommodating chambers **11**A aligned in the six rows at the left side of the terminal accommodating portion **11** have small box portions **13**A. The tabs **81** enter the box portions **13**A of the female terminal fittings **13** as the two housings **10**, **80** are connected to establish electrical connections between the mating terminal fittings. Laterally-extending preventing-rib receiving grooves **11**E are formed in the front surface at the left side of the terminal accommodating portion **11** where the six rows of the terminal accommodating chambers **11**A are aligned. The preventing-rib receiving grooves **11**E are configured to receive the error-assembling preventing ribs **84**.

A connector seal **90** is mounted from the front on the outer peripheral surface of the terminal accommodating portion **11** and is positioned at a step **19** between the terminal accommodating portion **11** and the fittable tube **12**. The connector seal **90** has a substantially rectangular ring shape and is made of a resilient material, such as a rubber, to provide sealing between the female housing **10** and the front mask **20**. Upper and lower guiding grooves **11**F extend substantially in the width direction at positions near the front ends of the upper and lower surfaces of the terminal accommodating portion **11** and receive elongated guiding projections **21** in the front mask **20**.

A substantially rectangular retainer mount hole **14** is formed in the right surface of the terminal accommodating portion **11**. The retainer mount hole **14** has a depth to communicate with all of the terminal accommodating chambers **11**A.

Partial locking projections **11**G and full locking projections **11**H for the front mask **20** are formed substantially side by side at the upper and bottom ends of a substantially widthwise middle part of the front surface of the terminal accommodating portion **11**. Recesses are formed at the substantially opposite sides of the partial and full locking projections **11**G, **11**H to receive locking claws **22** of the front mask **20**. Thus, the front mask **20** can be held at a partial locking position and at a full locking position.

An accommodation space **12**S is formed in the fittable tube **12** for receiving the seal **40** (see FIG. **24**), and the inner peripheral surface of the accommodation space **12**S is held in close contact with the outer peripheral surface of the seal **40**. The seal **40** is accommodated in a substantially a front-half area of the fittable tube **12**, and a base **51** of the

rear holder **50** is accommodated into a rear area of the fittable tube **12** (see FIG. **25**).

Engaging ribs **15** are formed at the front ends of substantially widthwise middle parts of both upper and bottom surfaces of the fittable tube **12** and extend in substantially forward and backward directions. The engaging ribs **15** have a dovetailed or undercut shape widened towards the projecting end and can slide along rib receiving grooves **52** in the rear holder **50**. Left and right guides **16** are formed at the opposite sides of the engaging rib **15** on each of the upper and lower surfaces of the fittable tube **12** and extend in forward and backward directions. The guides **16** slide along guidable grooves **53** formed in the rear holder **50** to guide a mounting operation of the rear holder **50**.

Left and right locking projections **17** are formed at substantially middle parts of the opposite side surfaces of the fittable tube **12** with respect to the height direction. Engaging portions **54** are formed at the rear holder **50** and resiliently engage the locking projections **17** to prevent the holder **50** from coming off backward. Slanted surfaces **17**A are formed at the rear of the locking projections **17** and slope in and towards the back. The engaging portions **54** slide smoothly on the slanted surfaces **17**A during the mounting of the rear holder **50**.

As shown in FIG. **12**, the front mask **20** has a front plate **23** for substantially covering the front surface of the terminal accommodating portion **11**. A side plate **24** projects back from the right edge of the front plate **23**. A ceiling plate **25** and a bottom plate **26** project back farther than the side plate **24** and are connected with the upper and lower ends of the front plate **23** and the upper and lower ends of the side plate **24**.

The front plate **23** has tab insertion openings **23**A at positions corresponding to the tabs **81** of the male housing **80**. The tab insertion openings **23**A communicate with the corresponding terminal accommodating chambers **11**A. The front plate **23** also has rib insertion openings **23**B at positions corresponding to the error-assembling preventing ribs **84** of the male housing **80**. The rib insertion openings **23**B communicate with the corresponding preventing-rib receiving grooves **11**E. Substantially round jig insertion openings **23**E are substantially vertically aligned in a row at the right end of the front plate **23** and can receive a jig or probe pin for an electrical connection test.

Upper and lower locking claws **22** are formed at upper and bottom ends of a substantially a widthwise middle part of the rear surface of the front plate **23**. The front mask **20** is displaceable between a partial locking position and a full locking position by movements of the front plate **23** substantially along the width direction along the front surface of the female housing **10**. In this case, the front mask **20** is held at the partial locking position by the resilient engagement of the locking claws **22** with the partial locking projections **11**G of the terminal accommodating portion **11** or is held at the full locking position by the resilient engagement of the locking claws **22** with the full locking projections **11**H of the terminal accommodation portion **11**.

The tab insertion openings **23**A of the front plate **23** are displaced slightly along the width direction from the front openings of the terminal accommodating chambers **11**A when the front mask **20** is at the partial locking position shown in FIG. **22**. Additionally, front walls **13**B of the box portions **13**A of the female terminal fittings **13** in the terminal accommodating chambers **11**A face the tab insertion openings **23**A. A jig **99** for an electrical connection test can be inserted through the tab insertion opening **23**A and into contact with the front wall **13**B of the box portion **13**A of the female terminal fitting **13**, as shown in FIG. **25**, while the front mask **20** is partly locked. Thus, the front plate **23** of the front mask **20** does not need separate jig insertion openings **23**E for each terminal accommodating chamber **11**A. The leading end of the jig **99** does not contact a tongue **13**F in the box portion **13**A, and hence cannot plastically deform the tongue **13**F. Further, a tapered guiding surface **23**F is formed around the opening edge of each tab insertion opening **23**A. Thus, the leading end of the jig **99** can be guided smoothly and accurately to the front wall **13**B of the box portion **13**A. When the front mask **20** is at the partial locking position, the corresponding tab insertion openings **23**A are not before the female terminal fittings **13** in the terminal accommodating chambers **11**A at the rightmost end. Therefore, the electrical connection test is conducted by passing the jig **99** through the jig insertion openings **23**E for exclusive use.

The tab insertion openings **23**A of the front plate **23** align with the front openings of the terminal accommodating chambers **11**A when the front mask **20** is at the full locking position. As a result, the tabs **81** can be inserted through the tab insertion openings **23**A and into the terminal accommodating chambers **11**A. Deformation spaces for the locks **11**B are formed during the molding of the female housing **11** and necessarily leave openings at the front surface of the terminal accommodating portion **11**. The front plate **23** of the front mask closes the front ends of the deformation spaces of the locks **11**B when the front mask **20** reaches the full locking position. Thus, external matter cannot intrude into the deformation spaces and inadvertently deform the locks **11**B.

An operating surface **24**A is formed at the outer side surface of the side plate **24** and can be pushed for moving the front mask **20** from the partial locking position to the full locking position. The side plate **24** contacts the right surface of the terminal accommodating portion **11** and is immediately before the opening edge of the retainer mount hole **14** when the front mask **20** reaches the full locking position. A retainer introducing recess **24**B is formed at a rear side of the side plate **24** for permitting the insertion of the retainer **30**.

Upper and lower elongated guiding projections **21** are formed at substantially middle parts of the ceiling plate **25** and the bottom plate **26** with respect to forward and backward directions and extend along the width direction. The guiding projections **21** slide along the guiding grooves **11**F of the terminal accommodating portion **11** to guide a sliding movement of the front mask **20**. Guiding-rib receiving grooves **27** are formed at positions on the ceiling plate **25** and the bottom plate **26** corresponding to the guiding ribs **85** of the male housing **80** and extend in forward and backward directions. The guiding ribs **85** move along the guiding-rib receiving grooves **27** to guide the connecting operation of the two housings **10**, **80**. The rear edges of the ceiling plate **25** and the bottom plate **26** are attached to the front edges of the upper and lower sides of the connector seal **90**, so that the connector seal **90** can be held tightly between these rear edges and the step **19**.

As shown in FIGS. **11** and **24**, the retainer **30** is a side type retainer, and has upper and lower substantially parallel arms **31** that project from a rectangular plate-shaped operating portion **32**. The operating portion **32** is configured to close the retainer mount hole **14**.

The arms **31** are substantially comb-shaped and side-by-side locking protrusions **33** project from the arms **31** at specified intervals corresponding to the arrangement of the terminal accommodating chambers **11**A. More particularly, two rows at the base end correspond to the large-size female

terminal fittings **13** and six rows at the leading side correspond to the small-size female terminal fittings **13**. Locking structures **34** are formed along the width direction on the front surfaces of both arms **31**. The retainer **30** can be held at a partial locking position and a full locking position by the engagement of the locking structures **34** with engaging structures (not shown) in the terminal accommodating portion **11**.

The operating portion **32** is spaced from the opening of the retainer mount hole **14** and the locking protrusions **33** are retracted sideways from the terminal accommodating chambers **11**A when the retainer **30** is at the partial locking position. On the other hand, the operating portion **32** closes the opening of the retainer mount hole **14** and the locking protrusions **33** enter the terminal accommodating chambers **11**A when the operating portion **32** is pushed sufficiently for retainer **30** to reach the full locking position. At this time, the locking protrusions **33** engage jaws **13**G at the rear ends of the box portions **13**A if the female terminal fittings **13** are inserted properly in the terminal accommodating chambers **11**A. As a result, the female terminal fittings **13** are locked doubly by the locks **11**B and the retainer **30**.

As shown in FIGS. **13** and **14**, the seal **40** is a substantially rectangular block having a specified thickness along forward and backward directions and is constructed as a one-piece wire sealing plug. The seal **40** has wire insertion holes **41** of circular cross section that normally are in a large-diameter state to enable insertion of the female terminal fittings **13** and the wires **18** from behind. Inner circumferential surfaces of the wire insertion holes **41** are brought into close contact with the outer circumferential surfaces of the wires **18** to provide hermetic sealing between the seal **40** and the wires **18**. The outer circumferential surface of the seal **40** closely contacts the inner circumferential surface of the fittable tube **12** to provide hermetic sealing between the seal **40** and the female housing **10**.

The wire insertion holes **41** aligned in two rows at the right side have a larger diameter substantially corresponding to the female terminal fittings **13** for larger currents, and the wire insertion holes **41** aligned in six rows at the left side have a smaller diameter substantially corresponding to the female terminal fittings **13** for smaller currents. Three inner lips **42** are formed circumferentially on the inner circumferential surfaces of the respective wire insertion holes **41**. Further, three outer lips **43** are formed circumferentially on the outer peripheral surface of the seal **40**. During the sealing by the sealing member **40**, the inner lips **42** are squeezed along the height direction by the wires **18**, and the outer lips **43** also are squeezed along the height direction by the inner peripheral surface of the fittable tube **12**.

The seal **40** is inserted into the front portion of the fittable tube **12** and then the base **51** of the rear holder **50** is inserted into the rear portion of the fittable tube **12**. As a result, the rear surface of the seal **40** is pressed by the front pressing surface **51**A of the base **51** of the rear holder **50**. More particularly, the seal **40** is compressed in the thickness direction between the pressing surface **51**A of the base **51** and the rear surface of the terminal accommodating portion **11** so that inside diameters of the wire insertion holes **41** are narrowed to bring the inner peripheral surfaces thereof into close contact with the wires **18**.

As shown in FIGS. **15** to **17**, the rear holder **50** is a cap having an open front surface. More particularly, the rear holder **50** has the rectangular block-shaped base **51** and a substantially plate-like projecting edge **55** extending at substantially at a right angle from the outer periphery of the rear end of the base **51**. Side portions **56**A, **56**B project forward from the projecting end of the projecting edge **55**, and substantially plate-like locking pieces **57** project back from the projecting end of the projecting edge **55**. The inner peripheral surfaces of the sides **56**A, **56**B are spaced apart by a substantially constant distance from the outer peripheral surface of the base **51** over substantially the entire periphery to define a fitting space for receiving the surrounding wall of the fittable tube **12** from the front.

Insertion paths **51**B are formed at positions of the base **51** substantially corresponding to the wire insertion holes **41** of the seal **40** and extend substantially in forward and backward directions. The insertion paths **51**B are configured to receive the female terminal fittings **13** and the wires **18** inserted into the corresponding wire insertion holes **41**. The insertion paths **51**B have substantially rectangular cross sections one size larger than the box portions **13**A. Thus, the female terminal fittings **13** and the wires **18** can be inserted loosely through insertion openings in the rear surface of the base **51**.

Left and right side plates **56**A and upper and lower lever mounting plates **56**B are formed on the rear holder **50**. Left and right engaging portions **54** are formed at middle parts of the opposite side plates **56**A with respect to the height direction and are resiliently deformable in and out. Upper and lower slits **56**E are formed at the front end of each side plate **56**A and at opposite sides of the engaging portion **54** so that the engaging portion **54** can deform resiliently between the slits **56**E. An engaging hole **54**A is formed substantially in the center of each engaging portion **54**. The engaging portions **54** move resiliently over the locking projections **17** as the rear holder **50** is fit on the fittable tube **12** to a proper depth, and the engaging holes **54**A of the engaging portions **54** then engage the locking projections **17** when the rear holder **50** is fit on the fittable tube **12** to a proper depth. As a result the front surfaces of the locking projections **17** engage front edges of the engaging holes **54**A. Clearances are left between the locking projections **17** and the opening edges of the engaging holes **54**A. The rear holder **50** can slide within a range of these clearances when the movable member **70** reaches a final stage as described below.

As shown in FIG. **15**, bulges **56**F are formed at widthwise middle parts of both lever mounting plates **56**B and are raised slightly with respect to the opposite sides thereof. Upper and lower rib receiving grooves **52** are formed in the bulges **56**F and open in the front surface and the inner peripheral surface and extend in forward and backward directions. The rib receiving grooves **52** have dovetail shapes corresponding to the engaging ribs **15** of the fittable tube **12**. The engagement of the rib receiving grooves **52** and the engaging ribs **15** prevents the lever mounting plates **56**B from being disengaged from the female housing **10** even if forces act on the lever mounting plates **56**B in directions to move them away from each other. Left and right guidable grooves **53** are formed at opposite sides of the rib receiving groove **52** of each lever mounting plate **56**B and extend in forward and backward directions. The guidable grooves **53** are at positions substantially corresponding to the guiding portions **16** of the fittable tube **12** and open in the front surface and the inner peripheral surface. The rear holder **50** is fit to the fittable tube **12** while being slidably guided by the guides **16** and the engaging ribs **15**.

Upper and lower pivot shafts **58** project from the outer peripheral surfaces of both bulges **56**F for rotatably supporting the lever **70**. Each pivot shaft **58** is cylindrical and front and rear widened portions **58**A bulge out from the projecting end thereof for preventing the disengagement of

the lever **70**. Further, left and right temporarily holding portions **56**G projects at the opposite lateral ends of the rear end of each lever mounting plate **56**B.

Two locking pieces **57** project back from upper and lower sides of the projecting edge **55**. The locking pieces **57** are substantially plate shaped and extend substantially parallel. Each locking piece **57** is resiliently deformable in and out and has a locking projection **57**A on the outer side surface thereof. An engaging piece **57**B is formed in an area of each locking piece **57** behind the locking projection **57**A and has substantially the same width as the locking projection **57**A.

As shown in FIGS. **18** to **20**, the lever **70** has two substantially parallel side plates **71**, each of which is formed with a cam groove **72**. The side plates **71** are joined by a coupling plate **73** that extends in a width direction. In other embodiments, the lever **70** may comprise only one side plate coupled to an operable portion. Left and right bearing holes **74** are formed in the side plates **71**, and the pivot shafts **58** are fit securely into the bearing holes **74**. The cam grooves **72** are curved and have openings in end of the respective side plates **72**.

The outer surface of each side plate **71** has a substantially L-shaped thinned portion **71**A. Two substantially parallel slits **71**B are formed along the inner edges of the thinned portion **71**A so that the thinned portion **71**A can resiliently deform more easily. A projection **71**E is formed on the inner surface of the thinned portion **71**A.

The pivot shafts **58** of the rear holder **50** are inserted through the bearing holes **74** so that the lever **70** straddles the rear holder **50**. Additionally the rear edges of the side plates **71** contact the temporarily holding portions **56**G. In this way, the lever **70** is held at a rotation starting position. The cam pins **86** of the male housing **80** face the entrances of the cam grooves **72** when the housings **10**, **80** are brought closer together. The coupling plate **73** then is operated to rotate the lever **70**. As a result, the cam pins **86** move along the cam grooves **72** and the two housings **10**, **80** are pulled towards each other to assist the connection. It should be noted that a deformation of the lever **70** to widen a spacing between the side plates **71** is prevented by the sliding contact of the flanges **86**A of the cam pins **86** with inner peripheral portions **72**A of the cam grooves **72**.

The lever **70** can be rotated further after the housings **10**, **80** have been connected. As a result, the base **51** of the rear holder **50** moves forward in the tube **12** and compresses the seal **40** in a thickness direction. Thus, a rotation stroke of the lever **70** is a sum of a stroke required to connect the two housings **10**, **80** and a stroke required to compress the seal **40**.

As shown in FIG. **21**, the wire cover **60** is essentially a cap with upper and lower side walls **61** and a rear wall **62** that curves along the rear ends of the side walls **61**. Wires drawn out through the rear surface of the rear holder **50** are guided by an inner surface **62**A of the curved rear wall **62**.

As shown in FIG. **21**, an inclined surface **62**B inclines up towards the front an outer surface of the rear wall **62** of the wire cover **60** at the left side, and a substantially straight surface **62**E extends along a width direction on an outer surface of the rear wall **62**. The coupling plate **73** of the lever **70** that has reached a rotation ending position contacts the straight surface **62**E of the rear wall **62**. A lever lock **63** is formed at a boundary between the straight surface **62**E and the inclined surface **62**B on the rear wall **62**. The lever lock **63** is resiliently deformable in and out in a substantially U-shaped cut **62**F in the rear wall **62**, and a locking projection **63**A is formed on the outer surface of the lever lock **63** for engaging the coupling plate **73** of the lever **70** in a returning direction of the lever **70**.

Two resiliently deformable lock receiving pieces **64** project forward from each side wall **61**. Each lock receiving piece **64** has a substantially U-shaped rim that surrounds a substantially rectangular lock receiving hole **64**A. The lock receiving pieces **64** engage the locking pieces **57** of the rear holder **50** as the wire cover **60** is mounted and the locking projections **57**A fit into the lock receiving holes **64**A. Additionally, the engaging pieces **57**B of the rear holder **50** pass through the lock receiving holes **64**A and move onto the outer surfaces of the opposite side walls **61** as the wire cover **60** is mounted, whereas the leading ends of the lock receiving pieces **64** pass the opposite sides of the engaging pieces **57**B to move onto the outer surfaces of the locking pieces **57**. In this way, the locking pieces **57** and the lock receiving pieces **64** overlap in the thickness direction to lock the wire cover **60** strongly to the rear holder **50**.

The connector is assembled by mounting the connector seal **90** from the front to the step **19** of the female housing **10**. The front mask **20** then is slid sideways along the guiding grooves **11**F of the terminal accommodating portion **11** and the front plate **23** of the front mask **20** is arranged on the front surface of the terminal accommodating portion **11**. As a result, the connector seal **90** is squeezed between the front mask **20** and the step **19**. Further, the arms **31** of the retainer **30** are inserted into the retainer mount hole **14** of the terminal accommodating portion **11** and the locks **34** hold the retainer **30** at the partial locking position.

The female terminal fittings **13** connected with the wires **18** are inserted through the insertion paths **51**B of the rear holder **50**, through the wire insertion holes **41** of the seal **40** and into the terminal accommodating chambers **11**A of the female housing **10**. The female terminal fittings **13** then are locked partly by the locks **11**B. The retainer **30** then is inserted deeper so that the locking protrusions **33** of the arms **31** enter the corresponding terminal accommodating chambers **11**A and fully lock the female terminal fittings **13**. In other embodiments, the female terminal fittings **13** may be locked only by the locks **11**B or only by the locking protrusions **33** rather than by both as in the illustrated embodiment.

The bearing holes **74** of the lever **70** then are supported rotatably on the pivot shafts **58** of the rear holder **50** so that the rear end of the lever **70** engages the temporarily holding portions **56**G of the rear holder **50**. The seal **40** then is fit into the accommodation space **12**S of the fittable tube **12**, and the base **51** of the rear holder **50** is fit on the fittable tube **12** from behind to place the sides **56**A, **56**B of the rear holder **50** on the outer peripheral surface of the fittable tube **12**. As a result, the engaging portions **54** of the rear holder **50** resiliently engage the locking projections **17** of the fittable tube **12**. In this state, the front surface of the seal **40** lightly touches the rear surface of the terminal accommodating portion **11**, and the rear surface thereof lightly touches the pressing surface **51**A of the base **51** of the rear holder **50**. Thus, the seal **40** is mounted without being compressed in the thickness direction. Thereafter, the wire cover **60** is to be mounted on the rear holder **50** from behind. More particularly, the lock receiving pieces **64** of the wire cover **60** resiliently engage the respective locking pieces **57** of the rear holder **50**; and the wires drawn out through the rear surface of the rear holder **50** are bent and guided at substantially a right angle by the inner surface **62**A of the rear wall **62** of the wire cover **60**.

The female housing **10** can be connected with the mating male housing **80** by positioning the receptacle **83** of the male

housing **80** in opposed relationship to the terminal accommodating portion **11** from the front, as shown in FIGS. **1** and **5**. The housings **10**, **80** then are brought closer to each other so that the guiding ribs **85** of the receptacle **83** enter the rib receiving grooves **27** of the front mask **20** and so that the cam pins **86** of the receptacle **83** enter the cam grooves **72** of the lever **70** (see FIGS. **2** and **6**). The lever **70** then is rotated by holding the coupling plate **73** of the lever **70**. As a result, the two housings **10**, **80** are pulled towards each other by a cam action of the cam pins **86** and the cam grooves **72**. The front surface of the front mask **20** contacts the front surface of the terminal mounting portion **82** at an intermediate stage of the rotation of the lever **70** and while the cam pins **86** are still before the extending ends of the cam grooves **72**. Thus, further approaching movement of the two housings **10**, **80** is hindered (see FIGS. **3** and **7**). In this properly connected state, the tabs **81** of the male terminal fittings are inserted to substantially proper depths in the box portions **13**A of the female terminal fittings **13** and the male and female terminal fittings are connected electrically.

The lever **70** is rotated further towards the rotation ending position to slide the sides **56**A, **56**B of the rear holder **50** along the outer peripheral surface of the fittable tube **12** and to move the base **51** of the rear holder **50** forward in the accommodation space **12**S of the fittable tube **12**. Thus, the seal **40** is squeezed in the thickness direction between the pressing surface **51**A of the base **51** and the back surface of the fittable tube **12**. Accordingly, the inner circumferential surfaces of the wire insertion holes **41** have their diameters narrowed, and the wires **18** are fastened and sealed tightly in radially inward directions (see FIG. **8**). The lever locking portion **63** of the wire cover **60** resiliently engages the rear edge of the lever **70** when the lever **70** reaches the rotation ending position to prevent a returning movement of the lever **70** and to prevent a separation of the two housings **10**, **80** (see FIG. **4**).

The thickness of the seal **40** is kept substantially constant until the two housings **10**, **80** substantially reach a properly connected position. However, the thickness of the seal **40** is reduced to Z in FIG. **8** as the lever **70** is rotated from the properly connected position of the housings **10**, **80** towards the rotation ending position. During this time, the locking projections **17** of the fittable tube **12** retract from the positions where they contact the front ends of the engaging holes **54**A of the engaging portions **54**, thereby defining clearances to the front ends of the engaging holes **54**A. The rear end of the fittable tube **12** substantially abuts the front surface of the projecting edge **55** of the rear holder **50** when the lever **70** reaches the rotation ending position. Accordingly, a moved distance of the sides **56**A, **56**B of the rear holder **50** along the outer peripheral surface of the fittable tube **12**, i.e. a compressed amount of the seal **40**, can be determined by visually confirming the positions of the locking projections **17** and a displacement amount X (see FIG. **7**) of the rear end of the fittable tube **12** with respect to the rear holder **50**.

As described above, instead of being assembled directly to the female housing **10**, the lever **70** is mounted on the rear holder **50** as a separate part. Thus, a construction to assemble the lever **70** is formed on the rear holder **50**, with the mold for forming the female housing **10** can be simplified.

Further, the wire insertion holes **41** of the seal **40** are kept in a larger-diameter undeformed state before the lever **70** is rotated. Thus, the female terminal fittings **13** and the wires **18** can be inserted easily. On the other hand, after the lever **70** is rotated to connect the two housings **10**, **80** properly, the base **51** of the rear holder **50** is moved forward to compress the seal **40** between the pressing surface **51**A of the base **51** and the back surface of the fittable tube **12**. Therefore the respective wire insertion holes **41** are deformed to have smaller diameters, and the wires **18** are held tightly in close contact with the inner circumferential surface of the wire insertion holes **41** to achieve secure sealing. As a result, it becomes possible to set larger hole diameters for the wire insertion holes **41** for accommodating larger female terminal fittings **13**. Further, the inner circumferential surfaces of the larger wire insertion holes **41** and the hole edges of the seal **40** are less likely to be damaged upon inserting the female terminal fittings **13**.

A second embodiment of the invention is described with reference to FIGS. **26** and **27**. A connector of the second embodiment is a nonwatertight connector, and has neither the seal **40** nor the connector seal **90**. However, the connector of the second embodiment has parts that can interchange with the first embodiment. Specifically, the female housing **10**, the front mask **20**, the retainer **30**, the lever **70** and the wire cover **60** are substantially identical to those of the first embodiment and these parts are not described again. However, the second embodiment has a rear part **50**A that differs from the holder **50** of the first embodiment, as described herein.

The rear part **50**A is essentially a cap with an open front. More particularly, the rear part **50**A has a base **51**Q, a projecting edge **55**, sides **56**A, **56**B and locking pieces **57**. The projecting edge **55**, the sides **56**A, **56**B and the locking pieces **57** have the same shapes as those of the rear holder **50**, and only the base **51**Q differs from that of the rear holder **50**.

More specifically, the length of the base portion **51**Q along forward and backward directions is approximately a sum of the corresponding length of the base **51** and the thickness of the seal **40** in the undeflected state. Accordingly, the base **51**Q can substantially the entire inner peripheral surface of accommodation space **12**S of the fittable tube **12** of the female housing **10**. As the base **51**Q is extended, the entire length of the insertion paths **51**B becomes longer than that in the first embodiment.

The female terminal fittings **13** and the wires **18** connected with the female terminal fittings **13** are inserted through one or more respective insertion openings in the rear surface of the base **51**Q and further enter the terminal accommodating chambers **11**A of the terminal accommodating portion **11** through the insertion paths **51**B. The insertion paths **51**B are substantially continuous in a lengthwise direction to the corresponding terminal accommodating chambers **11**A. Thus, the female terminal fittings **13** have their inserting operations guided without interruption, thereby enabling smooth inserting operations.

The second embodiment is selected if watertightness is not required for a connector. Thus, the rear part **50**A is fit into the accommodation space **12**S of the fittable tube **12** of the female housing **10**. On the other hand, the first embodiment is selected if watertightness is required. Thus, the seal **40** and the rear holder **50** are fit sequentially into the accommodation space **12**S of the fittable tube **12**. More specifically, two kinds of rear members, i.e. the rear holder **50** and the rear part **50**A are prepared, and the appropriate rear member **50** or **50**A is selected depending on the need for watertightness. As a result, the application of the connector can be selected in a wider range.

As described above, the female housing **10** can be used commonly by selecting the rear holder **50** or the rear part **50**A depending on whether watertightness is required and mounting the selected one on the female housing **10**. As a

result, the number of kinds of parts can be reduced since connectors are not special products for the respective specifications.

The invention is not limited to the above described and illustrated embodiments. For example, the following embodiments are also embraced by the technical scope of the present invention as defined by the claims. Beside the following embodiments, various changes can be made without departing from the scope and spirit of the present invention as defined by the claims.

The base of the rear holder has a considerable length along forward and backward directions in the first embodiment. However, the base may be plate-shaped according to the present invention.

The seal is not compressed in the thickness direction until the two housings are connected properly in the first embodiment. However, the seal may be compressed to a certain extent by the pressing surface of the rear holder before the two housings are connected properly. The lever then may be rotated to the rotation ending position so that the pressing surface of the rear holder presses the seal further to provide secure sealing.

The front mask, the retainer, the connector seal and the wire cover are provided in the first embodiment, some or all of them may not be provided according to the present invention.

The above-described connector has a rotatable lever for displaying a cam action to connect the housings. However, any other movable member or lever displaying a cam action but having a different path (such as a substantially linear, elliptic, bent or other path) such as a slider may be used according to the invention for connecting the housings.

What is claimed is:

1. An electrical connector, comprising:

a housing having opposite front and rear ends, terminal accommodating chambers extending through the housing for accommodating terminal fittings along an insertion direction, an accommodation space provided at the rear end of the housing;

a seal selectively positionable in the accommodation space and being held in close contact with a peripheral sealing surface of the accommodation space;

a first rear member formed separately from the housing and selectively mounted on the rear end of the housing, the rear member having insertion openings for receiving the terminal fittings along the insertion direction of the terminal fittings into the terminal accommodating chambers;

a second rear member selectively mountable to the housing when no seal is accommodated in the accommodation space, the second rear member including a base to be fit into the accommodation space and formed with insertion paths extending from insertion openings formed in the rear surface of the base to the corresponding terminal accommodating chambers; and

a lever assembled with one of the first and second rear members and having at least one cam groove configured for receiving at least one cam pin formed on the mating housing and guiding the cam pin along the cam groove as the lever is rotated about at least one pivot shaft for connecting the housing with a mating housing through a cam action.

2. The connector of claim **1**, wherein the seal is formed with wire insertion holes that normally are in a large-diameter state, so that the terminal fittings and wires connected with the terminal fittings can be inserted therethrough.

3. The connector of claim **2**, wherein the rear member has a pressing surface for pressing a rear surface of the seal, the insertion openings in the rear member being dimensioned for loosely accommodating the terminal fittings and the wires and being aligned substantially with the respective wire insertion holes of the seal.

4. The connector of claim **2**, wherein the pressing surface of the rear member is dimensioned to compress the seal in a thickness direction by operating the movable member after the two housings are connected for narrowing diameters of the wire insertion holes sufficiently to bring inner circumferential surfaces of the wire insertion holes into close contact with the wires in a hermetic manner.

5. The connector of claims **4**, wherein the rear member includes a side for at least partly surrounding an outer peripheral surface of a rear part of the housing, the side being relatively displaceable along the outer peripheral surface of the rear part of the housing until the compression of the seal is completed.

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